THE
INDIAN FORESTER

(FOUNDED IN 1875)

Focus on Teak

VOL. 121 JUNE 1995 NO. 6

BOARD OF MANAGEMENT

Chairman - M.F. AHMED, I.F.S., Inspector General of Forests, Govt. of India, New Delhi.
Vice Chairman - D.N. TEWARI, I.F.S., Director General, Indian Council of Forestry Research & Education, Dehra Dun.

MEMBERS

Andamans : C.P. OBERAI, I.F.S; Andhra Pradesh : C.N. RAO, I.F.S.; Arunanchal Pradesh : G.P. SHUKLA, I.F.S.; Assam : R.N. HAZARIKA, I.F.S.; Bihar : P.N.SINGH, I.F.S.; Dadra & Nagarhaveli : ANIL MISRA, I.F.S.; Goa : S.S. CHOUDHURY, I.F.S.; Gujarat : R.L. JAVA, I.F.S.; Haryana: P.S. MALIK, I.F.S.; Himachal Pradesh : V.P. MOHAN, I.F.S.; Jammu & Kashmir : MIR INAYATULLA, I.F.S.; Karnataka: S. PARAMESHWARAPPA, I.F.S.; Kerala: G. MUKUNDAN, I.F.S.; Maharashtra: Dr. A.G. RADDI, I.F.S.; Madhya Pradesh: M.J. OKA, I.F.S.; Manipur :TH. N. SINGH, I.F.S.; Meghalaya:B. SINGH, I.F.S.; Mizoram: S.R. MEHTA, I.F.S.; Nagaland: K.I. AO, I.F.S.; Orissa: S. BOSE, I.F.S.; Punjab: Y.P. CHOWDHRY, I.F.S.; Rajasthan : A.B. MATHUR, I.F.S.; Sikkim: N.C. SENGA, I.F.S.; Tamil Nadu: M. HARIKRISHNAN, I.F.S.; Tripura; D. NAG, I.F.S.;Uttar Pradesh : ; West Bengal: G.S. MANDAL,I.F.S.; Dehra Dun: N.K. JOSHI, I.F.S.

RULES OF MANAGEMENT

1. *Pre-Payable Annual Subscription*

INDIA (Inclusive of Postage)	FOREIGN	SINGLE COPY (Current and Back issue) (Exclusive of Postage)
Rs. 400	$100.00 (By Sea Mail) $150.00 (By Air Mail)	India Rs. 40.00 Foreign $ 10.00

Note : - Subscriptions are generally booked for Calender Year (JANUARY-DECEMBER).

2. *Concessional Rates of Annual Subscription* (Applicable to Serving Forest Officers & Forest Scientists in Government Institutes and Government Departments in India only) :-
   Those drawing a Salary of less than Rs. 2000.00 p.m. ... ... Rs. 200.00 per Annum
3. *Life Subscription* :- Rs. 1,500/- (for retired forest officer, in India), Rs. 2,500/- (to individuals) and Rs. 10,000/- (to private sector companies)
4. *Advertisement Tariff* :- (The rates liable to charge WITHOUT NOTICE) All Advertisement Matter is strictly subject to the approval of the Management.

Space	12 Insertions	6 Insertions	3 Insertions	Casual (Per Insertion)
Full Page	3,750/-	2,000/-	1,125/-	375/-
Half Page	2,250/-	1,250/-	750/-	250/-
Qr Page	1,500/-	950/-	560/-	200/-
2.5 cm Across	1,250/-	750/-	500/-	175/-

Note :-

(1) Art work in black ink accepted. Drawings or art work of all description and/or other Advertisement material; are to be supplied by the advertising parties themselves. For halftones, positives to be provided.

(2) Screen used for Advertisement: 100.

(3) Only one Voucher Copy will be supplied. Overall Size : 24 cm x 18.5 cm; Printing Size (Full-Page) 19 cm x 14 cm. *Important* (a) Advertisement charges are strictly Payable in advance preferably by bank Draft on State Bank of India, Dehra Dun U.P. (India) and drawn in favour of the Business Manager *Indian Forester*. (b) The Advertisement matter, which should be TYPE WRITTEN IN BLOCK LETTERS should be sent in DUPLICATE. For further particulars and terms of business please apply to the Business Manager, Indian Forester.

(4) Correspondence concerning subscription, etc., should be addressed to the Business Manager, *Indian Forester*, P.O. New Forest, Dehra Dun (India). All payments on account of Subscription and Advertisement, etc., must be made in the name of the Business Manager, *Indian Forester* and Cheques, etc., drawn in his favour.

(5) All complaints regarding delay in receipt or non-delivery of copy or copies of the *Indian Forester* should be made WITHIN 30 DAYS from the due date of publication of an issue which is Ist of each month to the Business Manager, *Indian Forester*, P.O. New Forest, Dehra Dun. Efforts will be made to supply duplicate copy or copies of the missing number, free of cost, provide a complaint is received in time, and on payment if a complaint is received after 30 days subject to the availability of a copy or copies in stock.

(6) In case of dispute, Dehra Dun, U.P. (India), shall be the place of jurisdiction.

4 - Oct 1995
600035

ISSN 0019-4816

THE INDIAN FORESTER

Volume 121 **No. 6**

JUNE, 1995

Focus on Teak

FRONT COVER

MODEL TEAK (*TECTONA GRANDIS*) NURSERY (MAHARASHTRA).

CONTENTS

EDITORIAL 445

ARTICLES

IMPROVED TECHNIQUE OF TEAK PLANTING.
Anil Mohan and P.K. Kulkarni........ 447

BIOMASS AND NUTRIENT DISTRIBUTION IN YOUNG TEAK (*TECTONA GRANDIS* LINN. F.) PLANTATIONS IN TARAI REGION OF UTTAR PRADESH.
M.S. Negi, V.N. Tandon and H.S. Rawat 455

EFFECTS OF CULLING ON PLANTING STOCK PRODUCTION IN TEAK NURSERY.
K. Subramanian, V.M. Gadbail, N. Rambabu and Mohan Jha 465

USE OF COPPICE SHOOTS IN SEED PRODUCTION AREAS OF TEAK : A NEW CONCEPT.
M.S. Rawat, D.P. Uniyal and C.J.S.K. Emmanuel... 469

SEWAGE WATER AS POTENTIAL FOR THE TREE GROWTH - A STUDY ON TEAK (*TECTONA GRANDIS*) PLANTATION.
M.G. Gogate, U.M. Farooqui and V.S. Joshi 472

SELECTION DIFFERENTIAL AND PREDICTED GENETIC GAIN IN *TECTONA GRANDIS*.
S.K. Bagchi 482

GROWTH RESPONSES TO IRRIGATION : EKSAL (AMBHADI) TEAK PLANTATION - A CASE STUDY.
M.G. Gogate, U.M. Farooqui and V.S. Joshi 491

A STUDY ON VOLUME ESTIMATION FOR INDIAN TEAK.
S.K. Chakrabarti and K.S. Gaharwar 503

EFFECT OF TEMPERATURE AND RELATIVE HUMIDITY ON GRAFTING AND BUDDING OF TEAK (*TECTONA GRANDIS* LINN. F.).
D.P. Uniyal and M.S. Rawat 510

A NOTE ON HEARTWOOD PROPORTION AND WOOD DENSITY OF 8-YEAR OLD TEAK.
K.M. Bhat 514

EFFECT OF VESICULAR ARBUSCULAR MYCORRHIZAE ON THE GROWTH AND MINERAL NUTRITION OF TEAK (*TECTONA GRANDIS* LINN. F.).
V.V.K. Durga and Sanjay Gupta........ 518

Contd...

CENTRAL
EDITORIAL BOARD

President :
N.K. JOSHI, I.F.S.

Hony. Editor :
PANKAJ KHULLAR, I.F.S.

DR. P.N. RAY, I.F.S
PRADEEP KHANNA, I.F.S.
V.K. WADHWA

EVALUATION OF SOME MEDICINAL AND NATURAL PLANT EXTRACTS AGAINST TEAK SKELETONIZER, *EUTECTONA MACHAERALIS* WALK.
P.B. Meshram 528

ASSOCIATION AND ACTIVITY OF ARBUSCULAR MYCORRHIZAE OF TEAK (*TECTONA GRANDIS*) IN CENTRAL INDIA.
R.K. Verma and Jamaluddin 533

ASSESSMENT OF DAMAGE CAUSED BY HEART-ROT IN TEAK IN MADHYA PRADESH.
N.S.K. Harsh and C.K. Tiwari 540

TEAK FRUIT TREATMENT MACHINE - A PROTOTYPE - II.
A.R. Bapat and M.M. Phulari 545

THE VIABILITY OF COMMERCIAL TEAK PLANTATION PROJECTS.
A.N. Chaturvedi 550

VALUE OF A 20-YEAR OLD IRRIGATED TEAK PLANTATION.
J.K. Rawat 553

TECTONA GRANDIS - ELITE MANAGEMENT.
R.S.R. Prasad 558

TEAK - HOW FAST CAN IT GROW AND HOW MUCH CAN IT PAY ?
S. Parameshwarappa 563

TECHNICAL AND FINANCIAL EVALUATION OF GREEN EQUITIES.
G.S. Kinhal 566

THE BOUNTY FROM THE TEAK TREE.
C. Jagannath Reddy 573

RESEARCH NOTES (I-III) 576

FOREST NOTES AND OBSERVATIONS 584

FROM THE INDIAN FORESTER -
ONE HUNDRED YEARS AGO

THE QUALITY OF QUICKLY GROWN TEAK-WOOD.
P.M. Lushington 585

LETTERS TO THE EDITOR (I-III) 587

* * *

VOLUME 121 **NUMBER 6**

THE
INDIAN FORESTER

JUNE, 1995

EDITORIAL

Primarily a native of India and Southeast Asia, Teak (*Tectona grandis* Linn.f) has long been admired and cherished for its strength, durability and fine grain. Excavation of ancient civilisations have revealed its usage in construction not only in India, but as far away as Persia (modern Iran) as well. The very name of the species translates into "Carpenters pride". No wonder then, that few timbers of the world have attracted such attention as Teak. The species has been introduced almost all over the world, in countries and regions as diverse as Japan and Kampuchea in Southeast Asia, Australia and Fiji in the Pacific region, almost all the countries in Africa, the Caribbean, and Brazil to Argentina in South America. Though Burma teak has long been held forth as the prime example of the best timber in the world, India is considered to be the centre of diversity of the species, spreading, as it does, over nearly 9 million hectares, from the southern extremity of the mainland, to the Vindhyas in Central India. Teak from Central India (CP Teak) is comparable to the best grown Burma teak in strength, durability and grain.

It is well known that the organised forestry sector in India was based upon teak exploitation, primarily in South India, but to that area as well goes the credit of being the home of the earliest teak plantations. The efforts of Connoly and Chathu Menon are recorded in forestry text books the world over, and the earliest plantations still stand in mute testimony of the tireless and painstaking efforts put in by them over 150 years ago. Since then teak has been planted extensively; both within and outside its natural zone of occurrence. Today India has over 0.5 million hectares of teak plantations, and a massive ongoing programme to plant up almost 50,000 hectares annually.

It would not be wrong to maintain that teak wood is probably the most thoroughly tested and investigated timber in India, and is also the most in demand. In fact, the qualities of teak timber are the standard against which other woods are measured and judged for various uses. Similarly, the silviculture, management, ecology and disease pattern of no other species has received as much attention as that of teak. Despite its high market price, teak wood still attracts the largest demand in the construction, plywood and furniture industry in India. It is therefore no surprise that considerable attention is still focused on investigating the full potential of the species and constantly seeking new strains and provenances that can provide higher yields, on a shorter rotation. The entry of the private sector into the area of teak plantations, in a big way, has proved the economic viability of the venture, and has provided the much needed fillip towards research on the species.

This issue of the *Indian Forester*, therefore, focuses on this much admired species, and includes papers on various aspects of growth, management, diseases, and uses of teak. We hope that it will provide much relevant information to our readers, many of whom have long been demanding such an issue.

Pankaj Khullar
Hony. Editor

IMPROVED TECHNIQUE OF TEAK PLANTING

ANIL MOHAN AND P.K. KULKARNI

West Nasik Project Division,
Forest Development Corporation of Maharashtra Ltd.,
Nasik (Maharashtra)

Introduction

India's population has crossed 844 million by 1991. On one hand population is increasing at high rate, on the other hand deforestation is faster (1.3 million ha, NRSA Data 1984). Whatever may be the human population growth rate and forest growth rate is just comparable in opposite direction, the former increases and later decreases. Forests in India are under unbearable biotic pressure. Out of 75 million ha of recorded forest area in the country nearly 37 million ha or 49% are degraded with less than 40% crown cover density. The growing stock at 65 m^3/ha is very low compared to the world average of 110 m^3/ha. Mean annual increment is low at 0.5 m^3/ha/yr against the world average of 2.1 m^3/ha/yr. The impacts of loss and degradation of forest are in the form of soil erosion, degradation of watershed area, loss of biological diversity, climatic changes and reduction in economic contribution of forests to human needs.

Urgent steps are required for restoring the green cover of area, improving land productivity and production of firewood, timber and other forest products.

The important measures in this regard are :

(a) Improving growing stock of the national forests to optimum level for achieving maximum productivity potential on sustainable basis.

(b) Restoration of degraded forests to productivity through replanting of sustainable species keeping in view the climatic condition and site characteristics.

(c) Breaking the negative patterns leading to continuous degradation by technological factors that limit the yields. Here we can think of technological changes now.

The projected requirements for 2010 A.D. are nearly thirteen times the maximum annual sustainable cut of 32 million m^3 based on current growing stock.

In order to match the demand, productivity of areas has to be enhanced by intensive plantations. This is the time when we have to go in for pragmatic productivity forestry.

Intensive Planting Method

Apart from genetic quality of the planting stock and inherent site quality, improved package of practices, adequate inputs and effective protection of plantations are important in determining productivity of plantations on different sites.

Here we are going to discuss the traditional teak planting technique vis-a-vis the improved technique. The traditional method consists of :

(a) Clearfelling the area.
(b) Burning and reburning of debris and brushwood.
(c) Alignment and staking of area with bamboo or small wood.
(d) Stumping in crow bar holes.

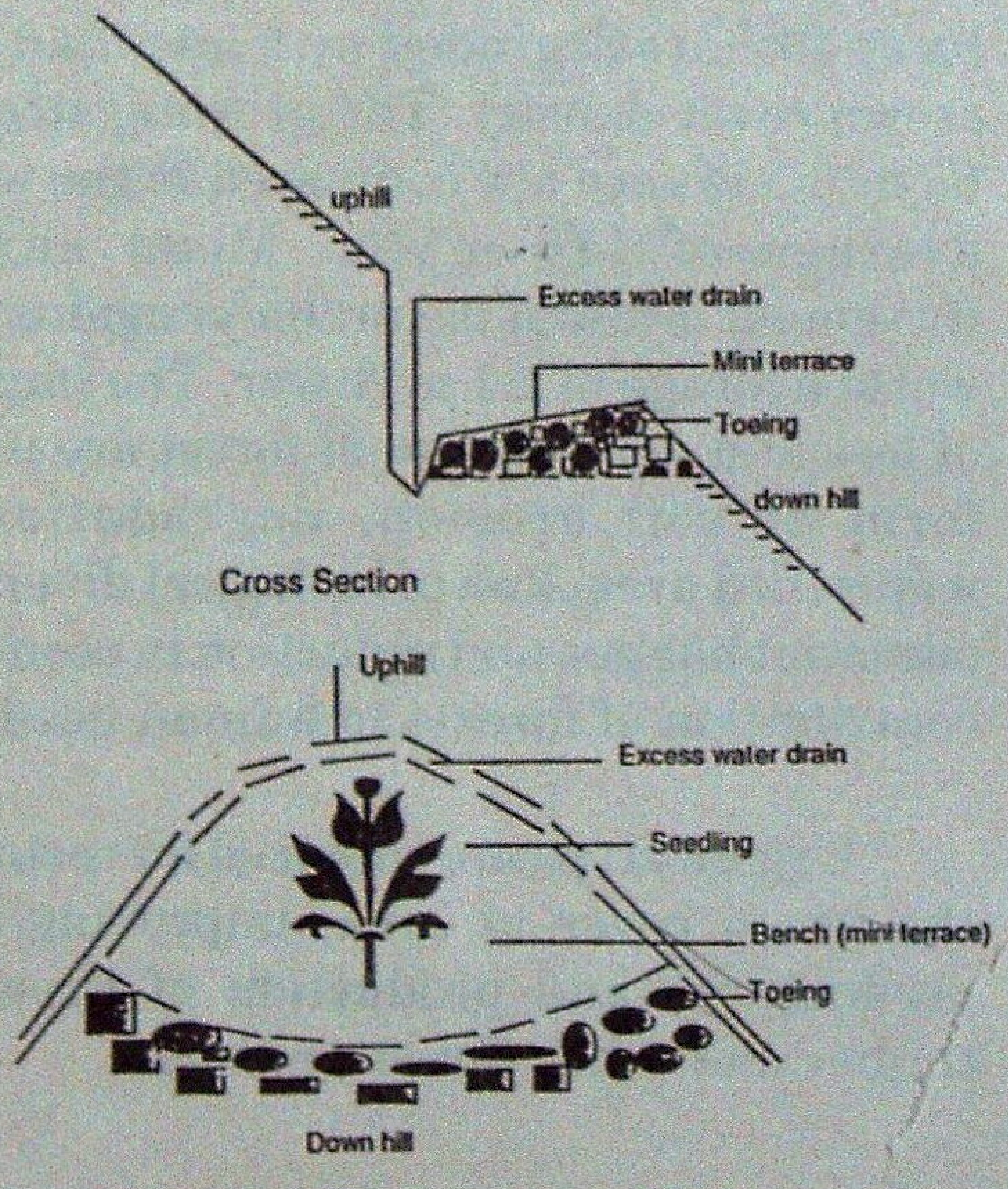
In this technique a huge biomass used to be burnt along with the humus of the soil. This burnt pulverised mass on slopy areas used to be washed off in high rainfall areas. Since Govt. of India has banned clearfelling, the brushwood is not available for burning as well. Procurement of staking material also means disturbing the bamboo growth in some other area and using the same for the purpose for which some alternatives can be thought of.

Under various plantation schemes, Teak is also being planted in degraded areas where humus is poor or wanting in soil. The idea of digging pits, refilling and stumping is fast picking up for teak plantation models which is a very costly technology. With this in background, we have tried and developed successfully an improved method of teak planting which is cost effective.

Technique discussed

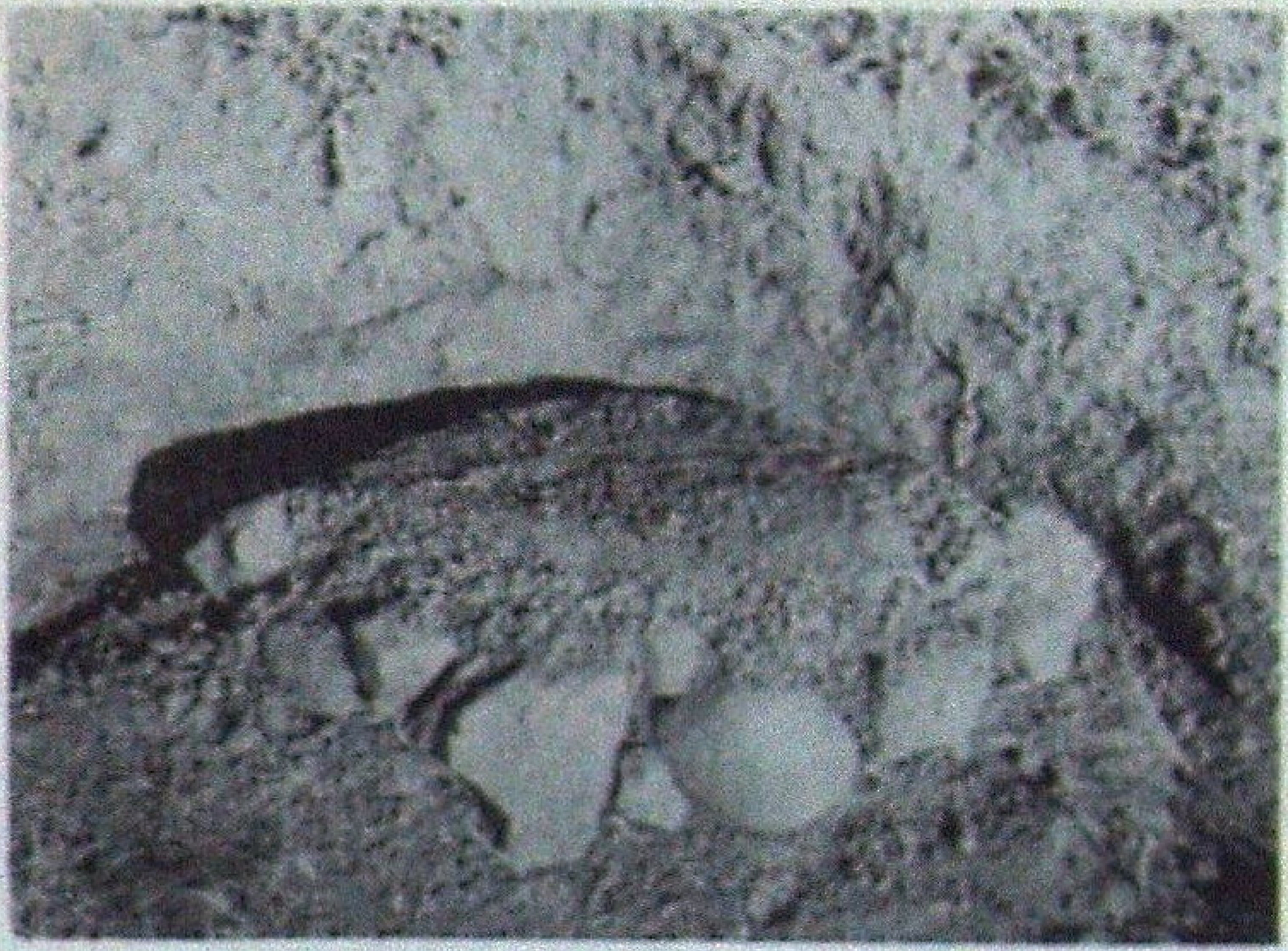
On the slopy areas of Western Ghats we have planted teak on Bench (Mini) terraces wherein the hill side is dug up at predetermined aligned spot and excavated soil is taken and deposited on the down hill side forming a bench like space. This bench is known as terrace and upper flat portion is called as step. Usually step of a terrace slopes down slightly into the hill. Width of a step varies with the degree of slope and texture of soil. Steeper the slope, the narrower the terrace is made. The soil collected in each step is supported with stones and available boulders so that it remains intact and soil is not eroded. Also we prepared excess rain water drain along up-hill side of semi-circular shape. The idea is to check the flow of water, fix the site of stumping and to retain soil moisture for a longer duration. The soil collected in the operation is broken, collected and neatly spread giving an inward slope. The toed soil forms a firm platform for teak planting. All care has been taken to drain out excess water. Stumping is carried out by crow bar technique on these mini-terraces. The

Fig. 1

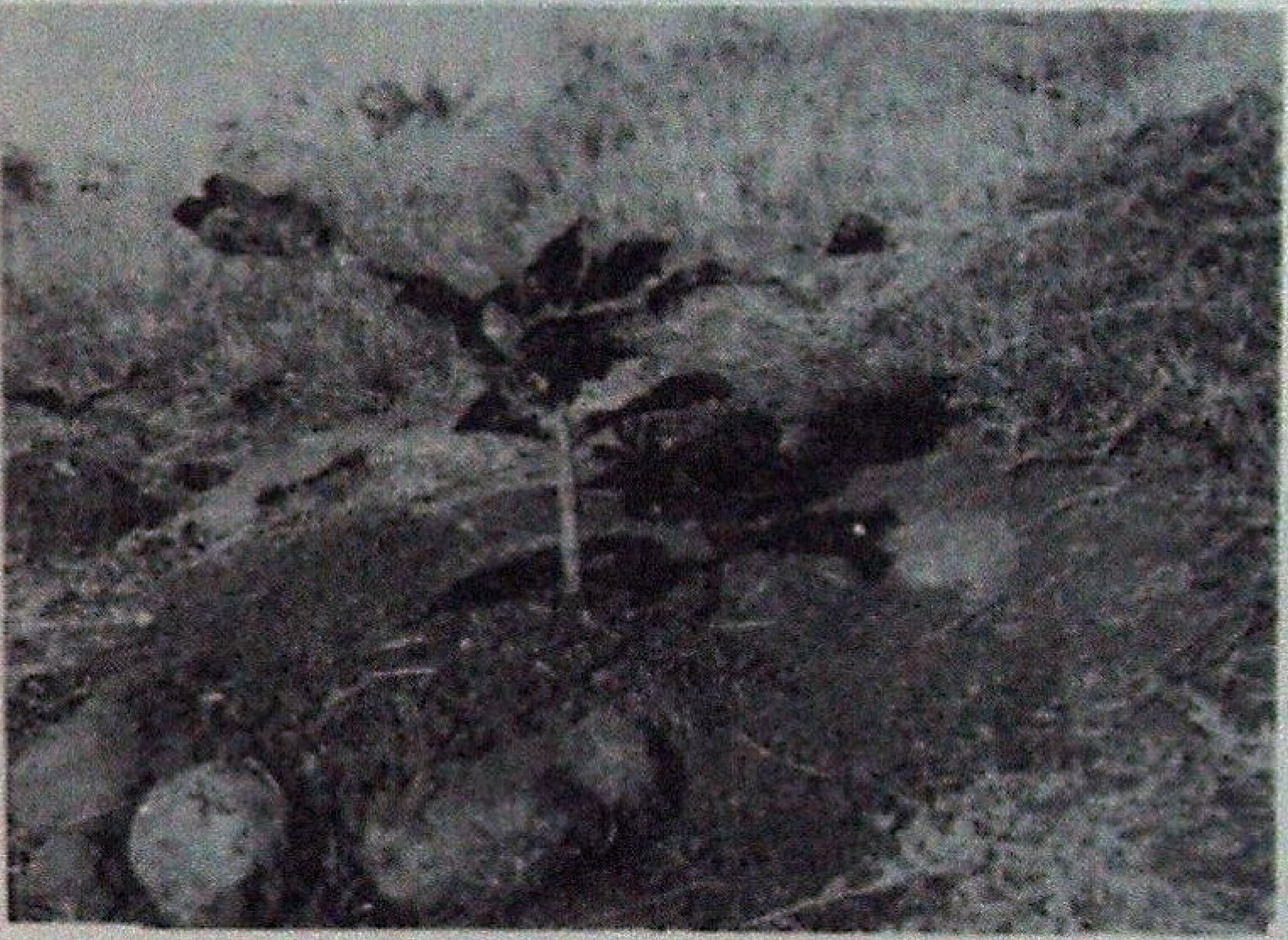


Plan of mini-terrace

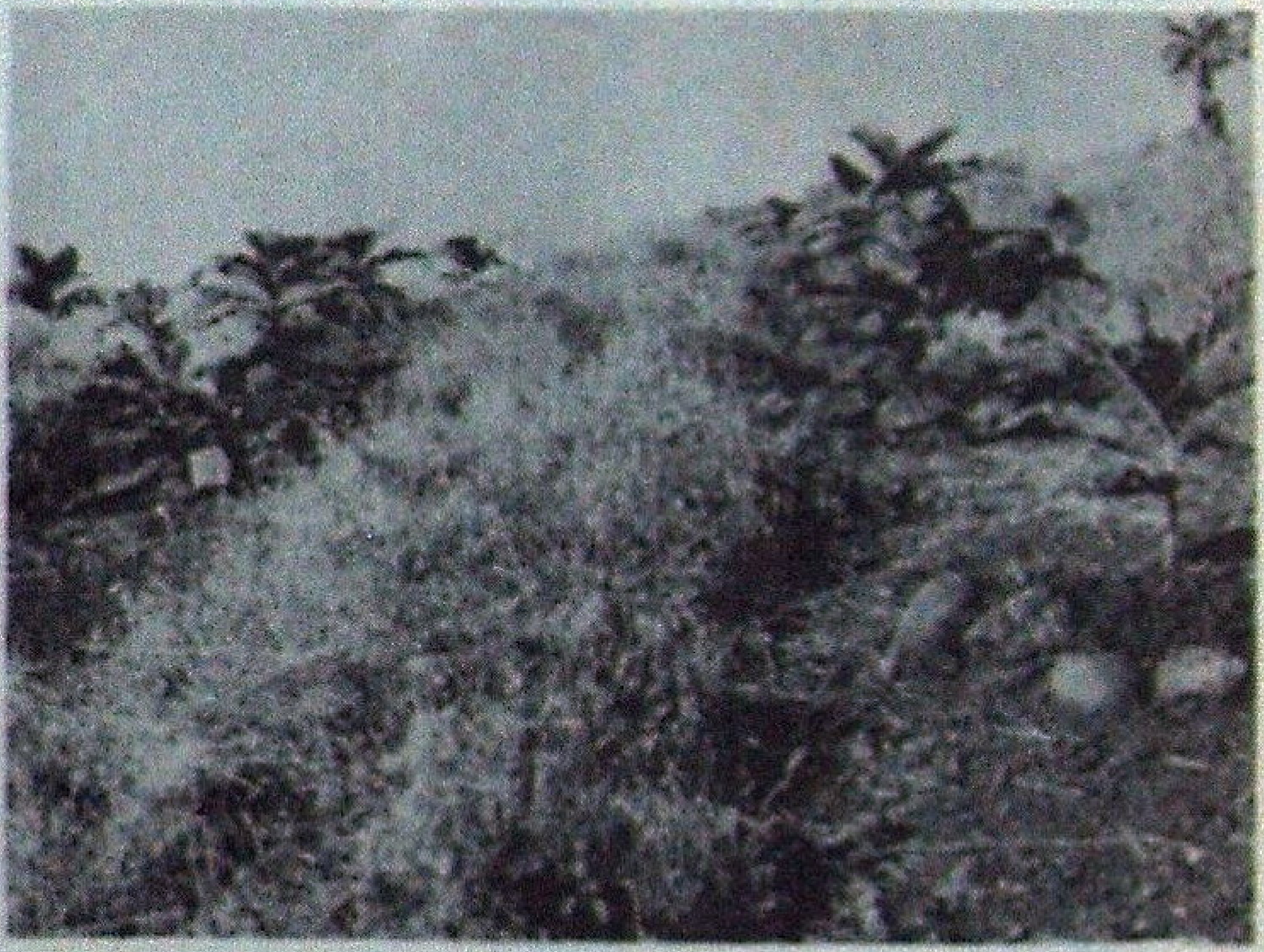
Area before treatment



Mini-terrace Front View

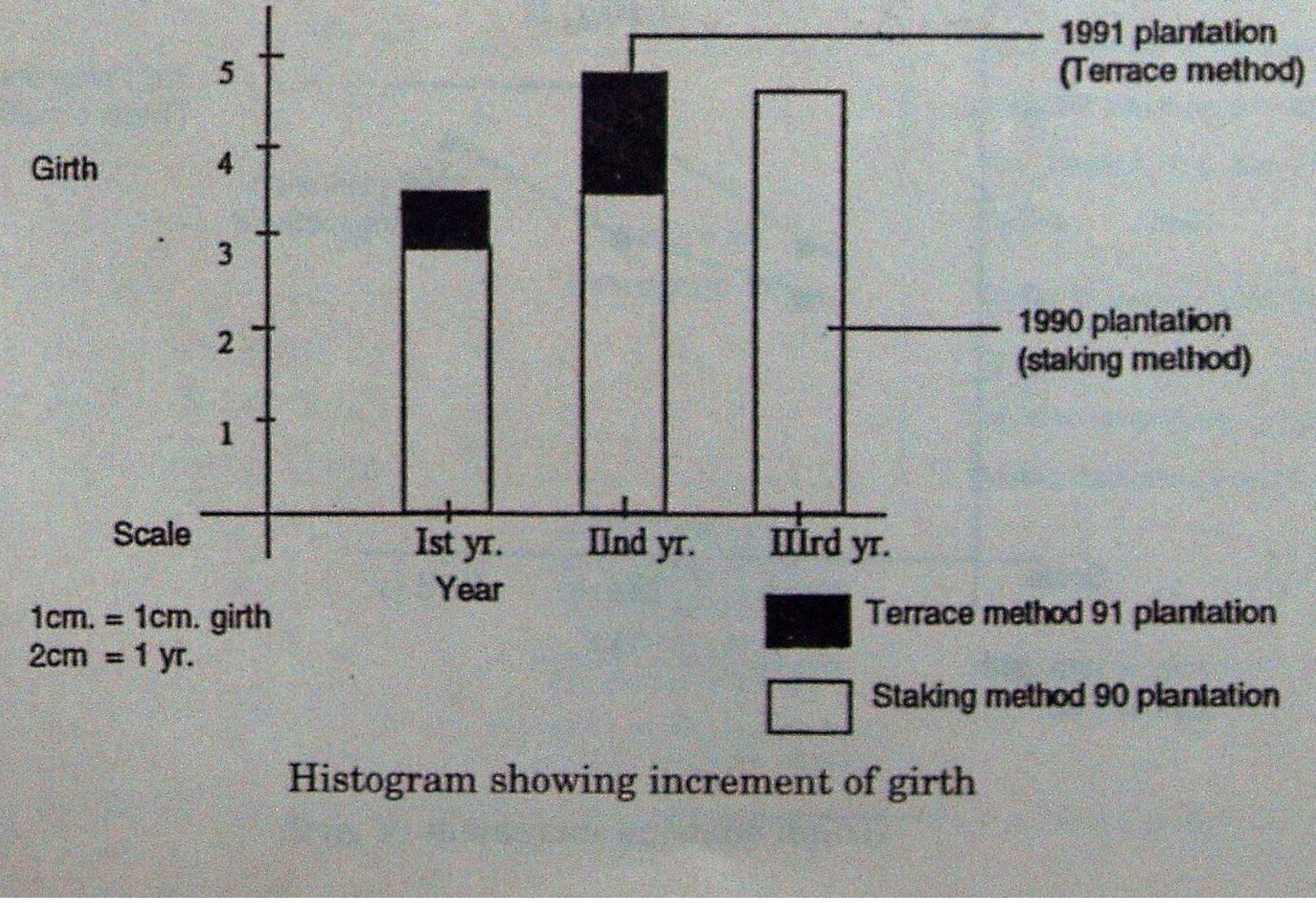


Teak on Mini-terrace Ist year

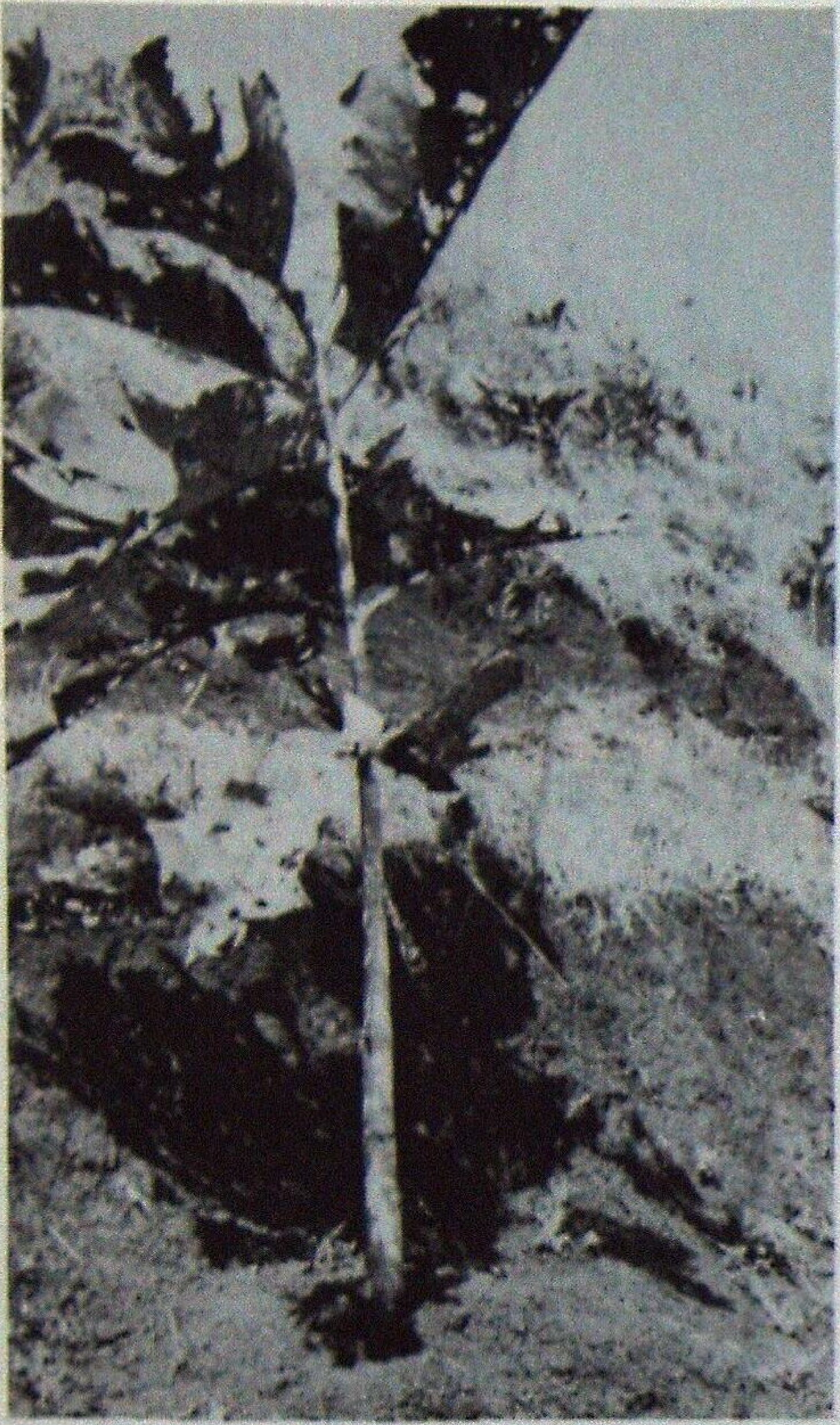


First year plantation an overview

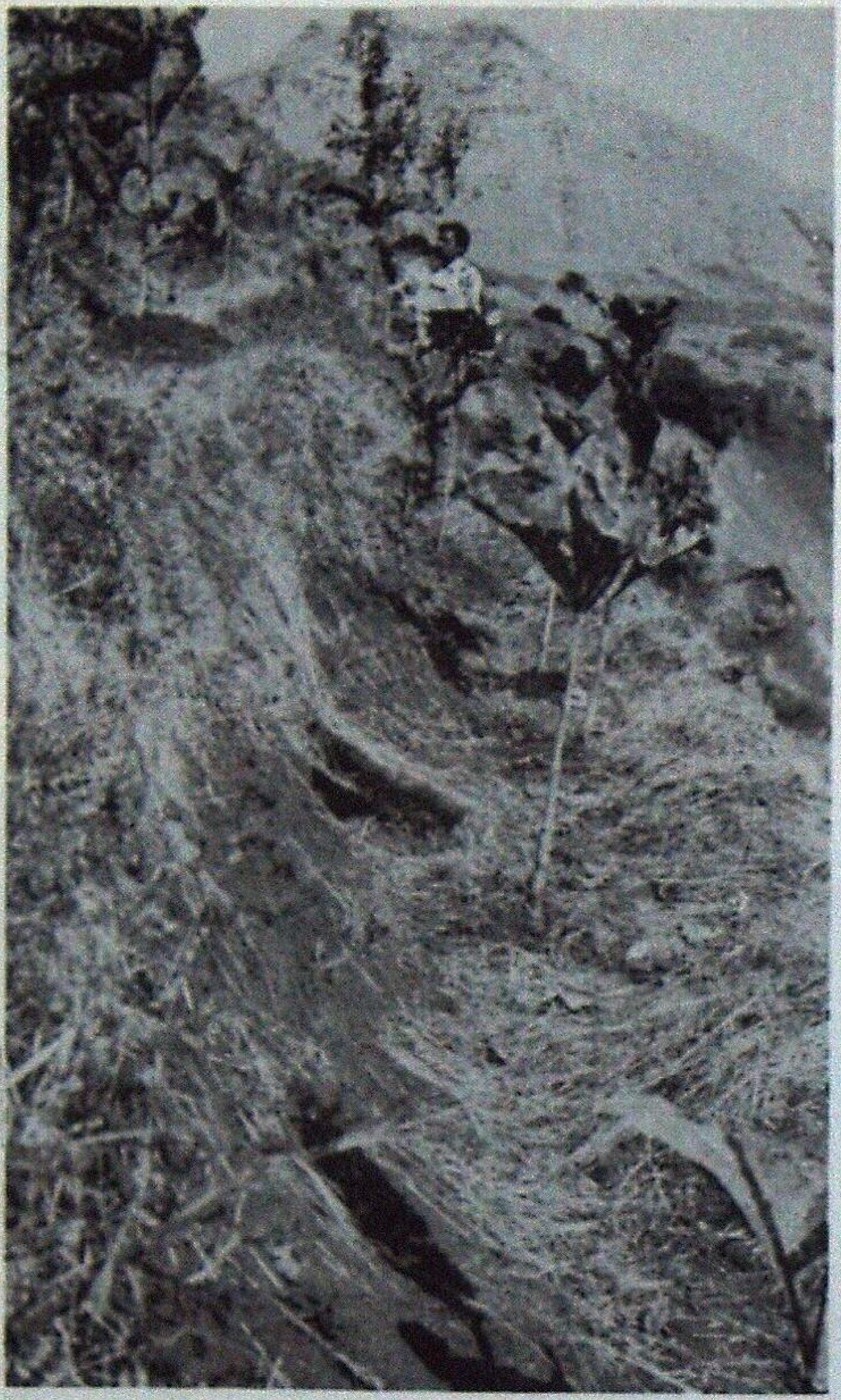
Fig. 2



Histogram showing increment of girth

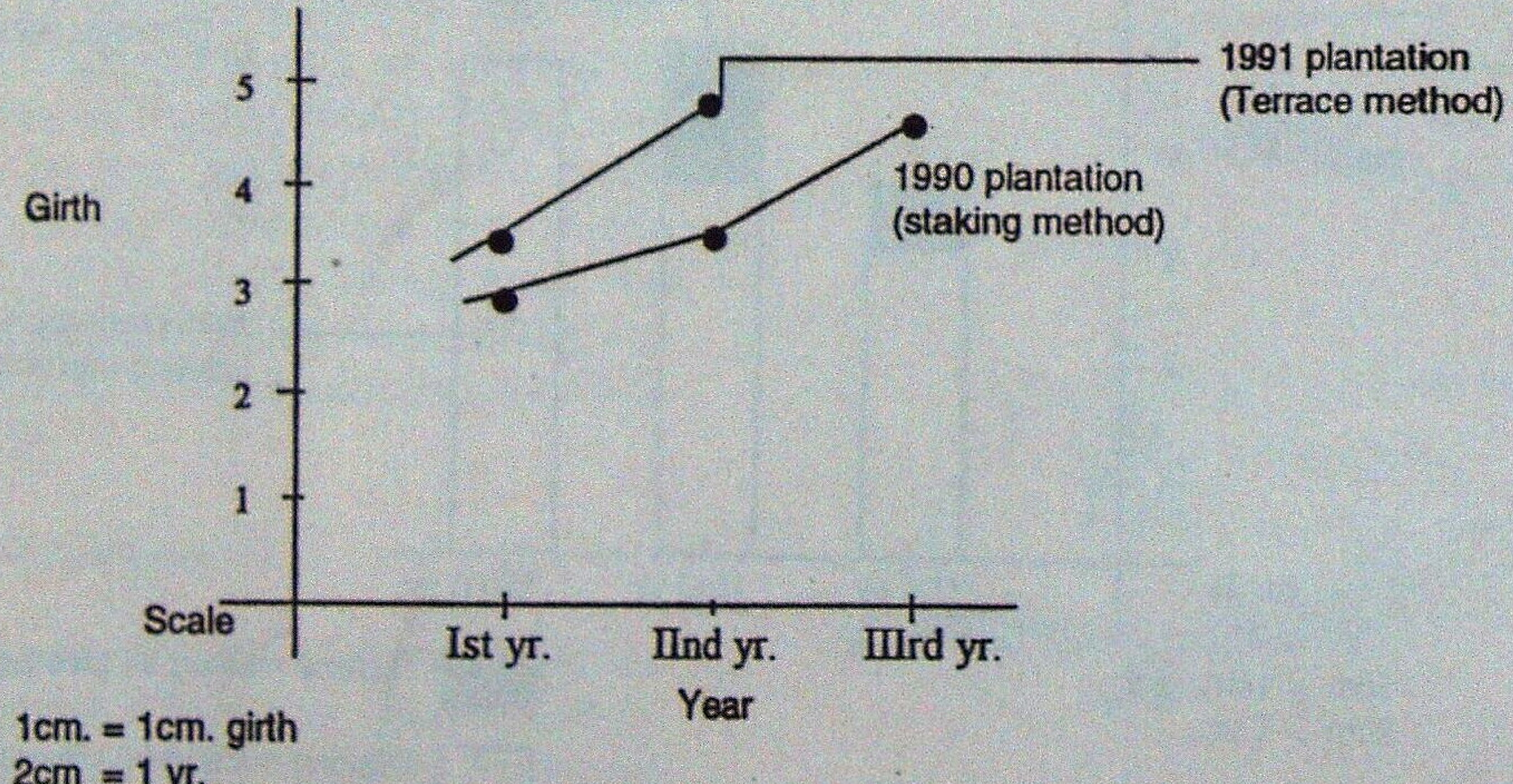


Teak on Mini-terrace 2nd year

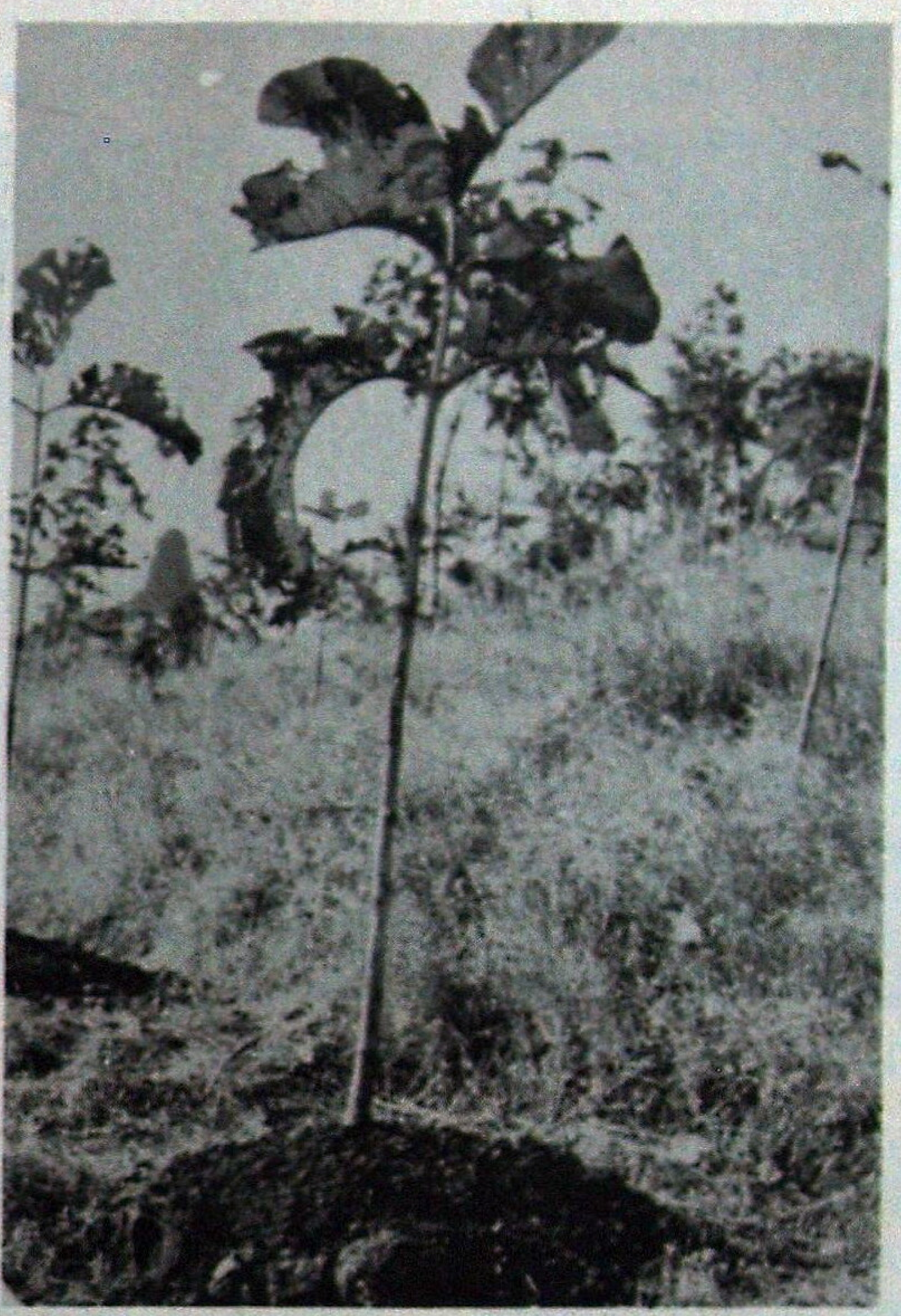


Second Year plantation
(Mini-terrace method)

Fig. 3

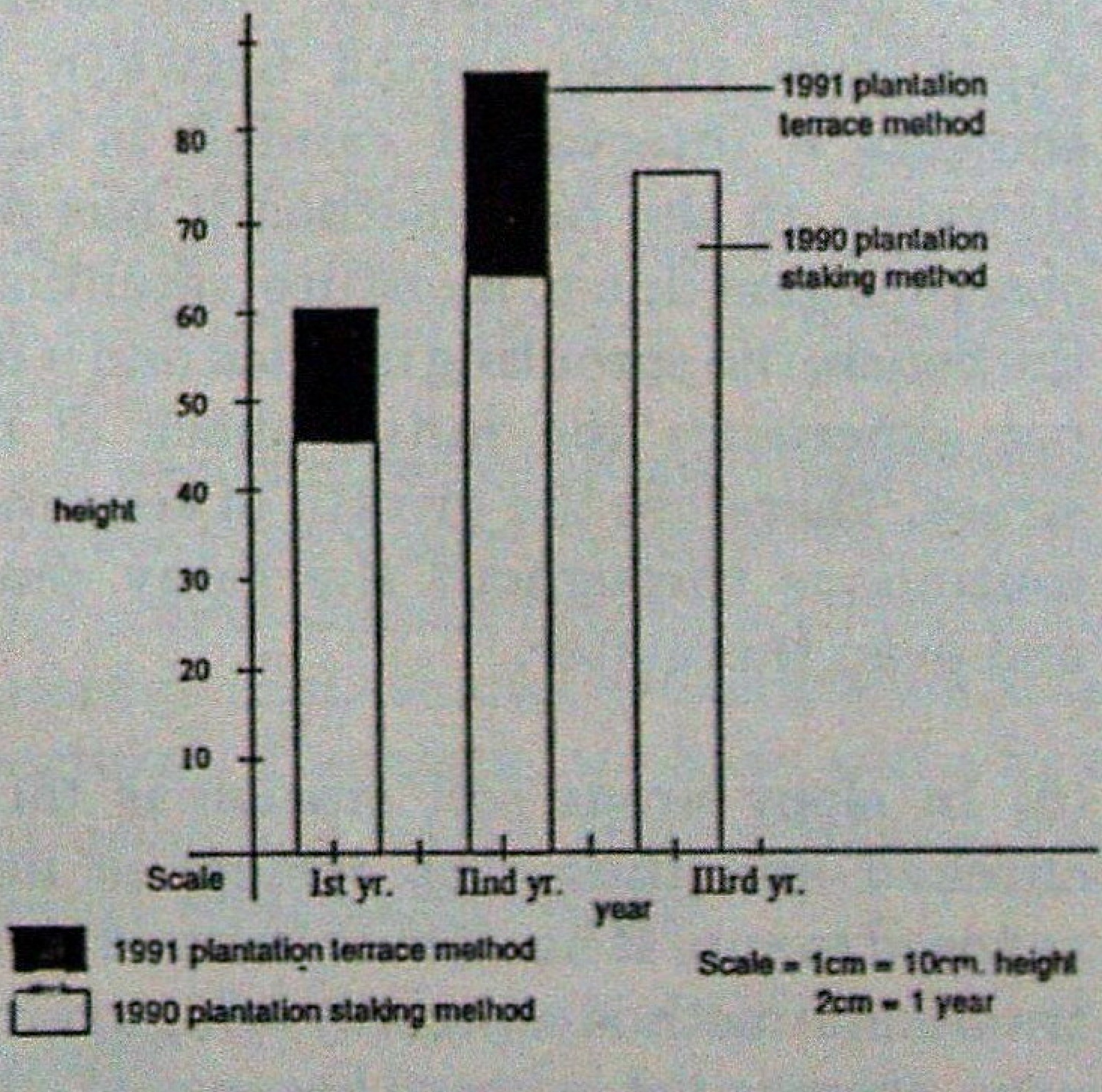


Graph showing increment of girth



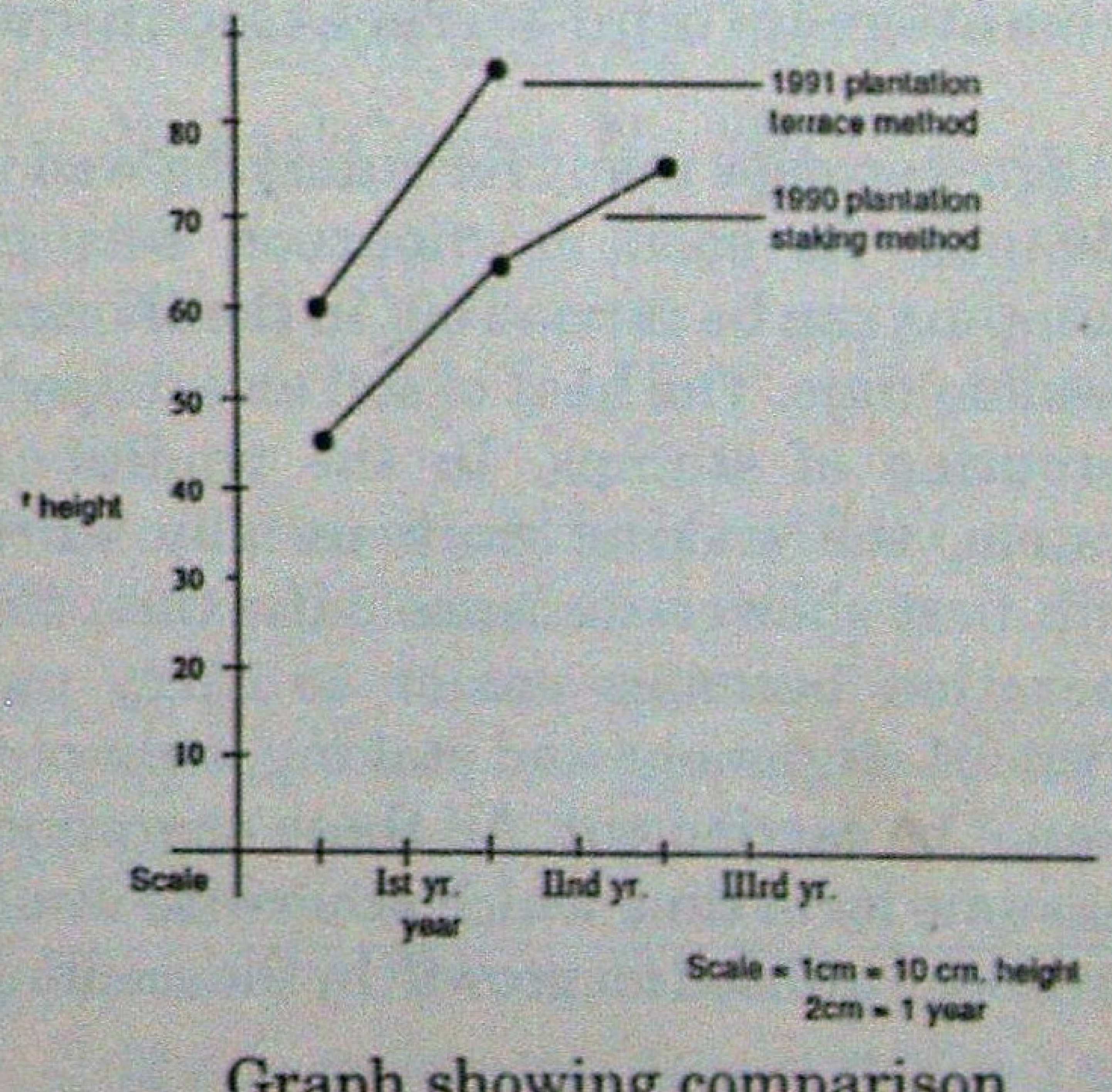
Teak on Mini-terrace 3rd year

Fig. 4



Histogram showing comparison of height increment

Fig. 5



Graph showing comparison of height increment

(Third Year Plantation (Mini-terrace method)

alignment of these small terraces would be as per the requirement of the scheme i.e. 2 m x2 m or 3 m x3 m (as the case may be). The work of preparation of mini-terraces are carried out as part of premonsoon operation.

Advantages of mini-terraces technique

(1) Site becomes ready for stumping well in advance. As soon as monsoon sets in, stumping can be carried out in the shortest possible time. The heat of soil also helps in sprouting of stumps. In the traditional system, the staking work usually starts with first showers because only then this operation becomes easier to carry out. Without alignment and staking, stumping cannot be carried out. All these operations consume lot of time which otherwise would have been utilised for growth by the seedling.

(2) Advance planning of entire planting works, labour procurement etc. can be effectively made.

(3) In this method there is no need to carry out staking in alignment. Mini-terraces remain prominent and intact. Thus the stake material is also saved to be cut from any other forest area permitting it to grow for the society.

(4) It has been observed that stumps experience stress period between two showers if interval of rainfall is more. However, in the new method it has been observed that due to moisture retention in the bench, the sprouting is quick and it does not experience the initial shock of rain stress. Therefore the growth of seedling is continuous throughout the rainy season and even thereafter.

(5) In slopy areas soil erosion is totally checked and thus root system is never exposed to sun. It has been observed that in traditional method especially in high rainfall area, stumps get exposed because of which root system does not develop timely.

(6) Run-off is checked. Excess water is

drained out for individual seedlings. Question of water-logging would not arise if inward slope to the bench has been given.

(7) On the bench, since the soil is worked extensively, weed growth around seedlings is minimised effectively and thus there is no chance of weeds overtopping the seedling. Time of weeding operations generally coincide with agricultural works due to which, operations get delayed for want of labourers. The above method takes care of this.

(8) Survival and growth (height and collar diameter) are better vis-a-vis the traditional method. It has been discussed in our result para substantiated by growth charts and graphs.

Cost discussed : We have carried out the work study for preparing mini-terraces. One labourer can prepare nearly 108 terraces in 8 hrs i.e. 9.2 mandays are required for 1000 mini-terraces. With the prevailing daily wage rate i.e. Rs. 29.10, the preparation cost for one mini-terrace would be Rs. 0.27. The provision of rate structure for transport and staking is 0.35 mandays/100 seedlings and also the stake cost of Rs 0.16 stake. Thus the provision exists for Rs. 0.23/ plant. Rest of the requirement out of same rate structure can be met in contingency amount.

If we compare cost effectiveness of mini-terrace system with pit method, we find the latter almost costing four times more than the former (Ref. Ghanekar Committee Rate structure). Therefore, we have come to a conclusion that mini-terrace system is cost effective with better results.

Results

In West Nasik Project Division of Forest Development Corporation of Maharashtra, we have tried the mini- terrace system since 1991 in some compartments of plantations. The growth pattern is as given in Tables 1 and 2.

Table 1

Data of average height and girth
(This data is based on 10% sampling)

When recorded	Height (cm)	Girth (cm)
1991 Plantation (Terrace method)		
F.S. Kawnai Comptt. No. 361		
Oct. 92	61	3.5
Oct. 93	87	4.8
1992 Plantation		
F.S. Kawnai Comptt. No. 341		
Oct. 92	30	2.10
Oct. 93	62.78	4.75
1993 Plantation		
F.S Kawnai Comptt. No. 361		
Oct. 93	27	1.5

Table 2

Data of average height and girth
(Based on 10% sampling)

When recorded	Height (cm)	Girth (cm)
1990 plantation (Staking method)		
F.S. Kawnai Comptt. No. 360		
Oct. 91	46	2.90
Oct. 92	65	3.50
Oct. 93	76	4.60
1990 plantation (Staking method)		
F.S, Kawnai Comptt. No. 341		
Oct. 91	50	3.60
Oct. 92	68	3.95
Oct. 93	80	4.75

If we compare the data of Tables 1 and 2, we find that growth pattern is in favour of terrace method where height increment is 30.81% more than traditional system. Similarly girth increment is 29.92% more than traditional system.

Table 3

Increment percentage of terrace system over traditional method

(a) Comptt. 361	Height	Girth
32.60%	Ist yr.	20.68%
33.84%	IInd yr.	37.14%
(b) Comptt. 341		
26%		31.94%
Average		
30.81%		29.92%

contd...

Therefore we are of the opinion that only this system should be adopted for planting teak.

SUMMARY

In this paper an improved method of teak planting which is cost effective, has been described in detail.

सागौन रोपण की परिष्कृत विधि

अनिल मोहन व पी० के० कुलकर्णी

सारांश

इस अभिपत्र में सागौन रोपण की परिष्कृत विधि विस्तार से बताई गयी है जो लागत की दृष्टि से भी प्रभावकारी

Snippets BIGGEST TEAK TREE

Biggest Teak (*Tectona grandis*) tree of India. Age about 600 years, height 45 m, girth 637 cm (B.H.) and seed still viable (81% germination). Sangam Range, Parambikulam Wild Life Sanctuary, Kerala.

BIOMASS AND NUTRIENT DISTRIBUTION IN YOUNG TEAK (*TECTONA GRANDIS* LINN. F) PLANTATIONS IN TARAI REGION OF UTTAR PRADESH

M.S. NEGI, V.N. TANDON AND H.S. RAWAT

Resource Survey and Management Division,
Forest Research Institute, Dehra Dun (India)

Introduction

Though teak forests have been created on large scale, at present no data is available to understand the effect of these monocultures on the site. Recently, Tewari (1992) has presented a comprehensive review of the work undertaken so far on this aspect. The purpose of this paper is to present data on (i) above and below ground biomass and its distribution among various tree components, (ii) the relationship between the tree parameters and the yield expressed as dry weight, (iii) the distribution of nutrients, to understand the effect of whole tree harvesting in an age series of young teak plantations.

Study Site

The studies were undertaken in 10, 20 and 30 years old Teak (*Tectona grandis* Linn. f) plantations, in Tarai Central Division of Uttar Pradesh. These plantations are situated in the zone of tropical moist deciduous forest types. The mean annual rainfall varies from 1300 mm to 1650 mm. The soil in alluvial loam and the undergrowth consist of few herbs and grasses.

Experimental Methods

The studies were conducted in 1992 using the harvesting method of stratified tree technique for estimating the biomass. A homogeneous patch was located in each stand and two to three temporary sample plots were laid out. At least 25 m buffer strip was left around each plot to ensure that stand development is not influenced by edge effects. The diameter (DBH) of all the standing trees within the plots were recorded. In order to have a better distribution of sample trees over the population for regression analysis, the whole diameter range in each stand was divided into three diameter classes and the sample trees were selected as being nearest to the average of each class (Ovington *et al.*, 1967). One root system of the sample tree having d.b.h. close to d.b.h. of the mean tree of the crop was excavated in each plantation for estimating the underground biomass. The oven dry weight of other sample trees (Table 1, marked with asterisks) have been calculated on the basis of the ratio of root biomass to above ground biomass. In all nine trees were sampled. Immediately after felling the sample trees, the fresh weight of each of the biomass component was recorded

Table 1

Component wise dry weight of sample tree (kg/tree) at different aged Tectona grandis plantations

Age (yrs)	Density per ha	Tree Category	Wood	Bark	Leaf	Twig	Branch	Total above ground biomass	Root	Total biomass
		A	40.132	7.868	8.640	5.507	7.800	69.947	15.710*	85.657
10	570	B	64.198	9.731	5.580	6.400	10.263	96.172	21.600	117.772
		C	105.484	14.750	11.520	12.133	25.230	169.117	37.983*	207.100
		A	26.065	8.304	2.667	6.240	3.690	46.966	9.490*	56.456
20	500	B	96.181	17.394	6.750	6.390	15.990	142.705	28.835	171.540
		C	171.903	31.529	17.480	16.200	43.240	280.352	56.648*	337.000
		A	58.593	11.363	5.700	8.690	9.571	93.917	16.473*	110.390
30	494	B	202.438	25.519	15.400	10.000	26.800	280.157	49.140	329.297
		C	336.303	37.693	25.999	33.600	119.467	553.062	97.008*	650.070

Note : Figures marked with asterisks are calculated values as roots were not sampled in these trees.

and representative samples of known weight were collected for oven dry estimation and chemical analysis.

The basic data of the sample trees (Table 1) were statistically analysed to obtain a set of regression equations for prediction of biomass on a regional basis to avoid the necessity of repeated destructive sampling to a great extent. Each biomass component was considered separately. The relationship between the oven dry weight and measurable features such as diameter at breast height and total height of trees were studied. Various linear models were tried using d.b.h. and height as independent variable. DBH alone was found to give reasonably precise values of biomass.

The regression equation developed for different characters along with the value of coefficient of determination (R^2) are given below :

Bole Biomass

$Y = 0.03343\ x^{2.73532}$ $R^2 = 0.98095$

Bark Biomass

$Y = 2.45896\ e^{0.0984x}$ $R^2 = 0.8915$

Leaf Biomass

$Y = -12.49108 + 1.253875x$ $R^2 = 0.9002$

Twig Biomass

$Y = 1.592118\ e^{0.0965x}$ $R^2 = 0.8526$

Branch Biomass

$Y = 0.570279\ e^{0.1823x}$ $R^2 = 0.9717$

Total above Biomass

$Y = 0.0758\ x^{2.6135}$ $R^2 = 0.9847$

Root Biomass

$Y = 0.0241\ x^{2.45322}$ $R^2 = 0.9803$

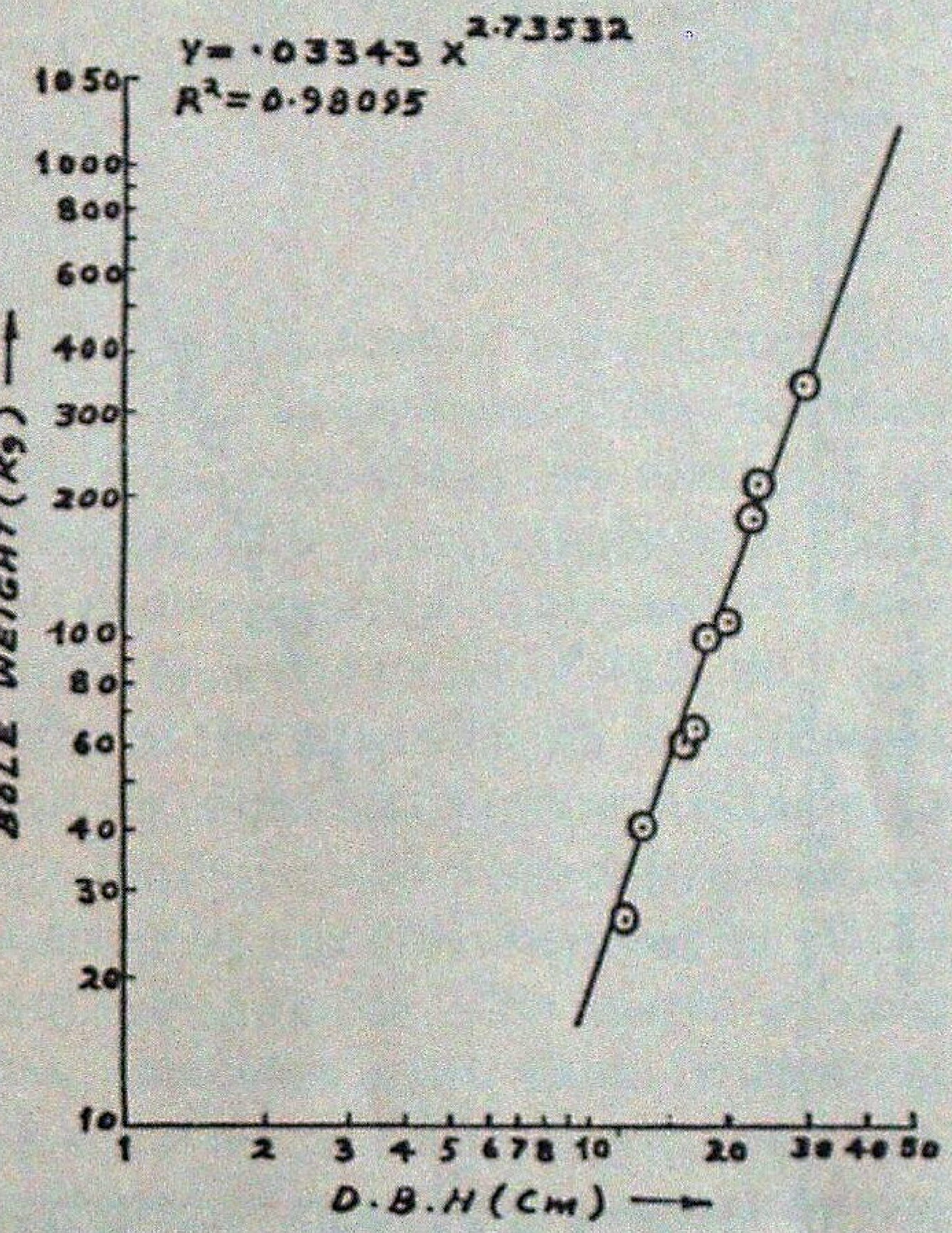
Total Biomass

$Y = 0.0982\ x^{2.5873}$ $R^2 = 0.9862$

Where Y is biomass and x is DBH

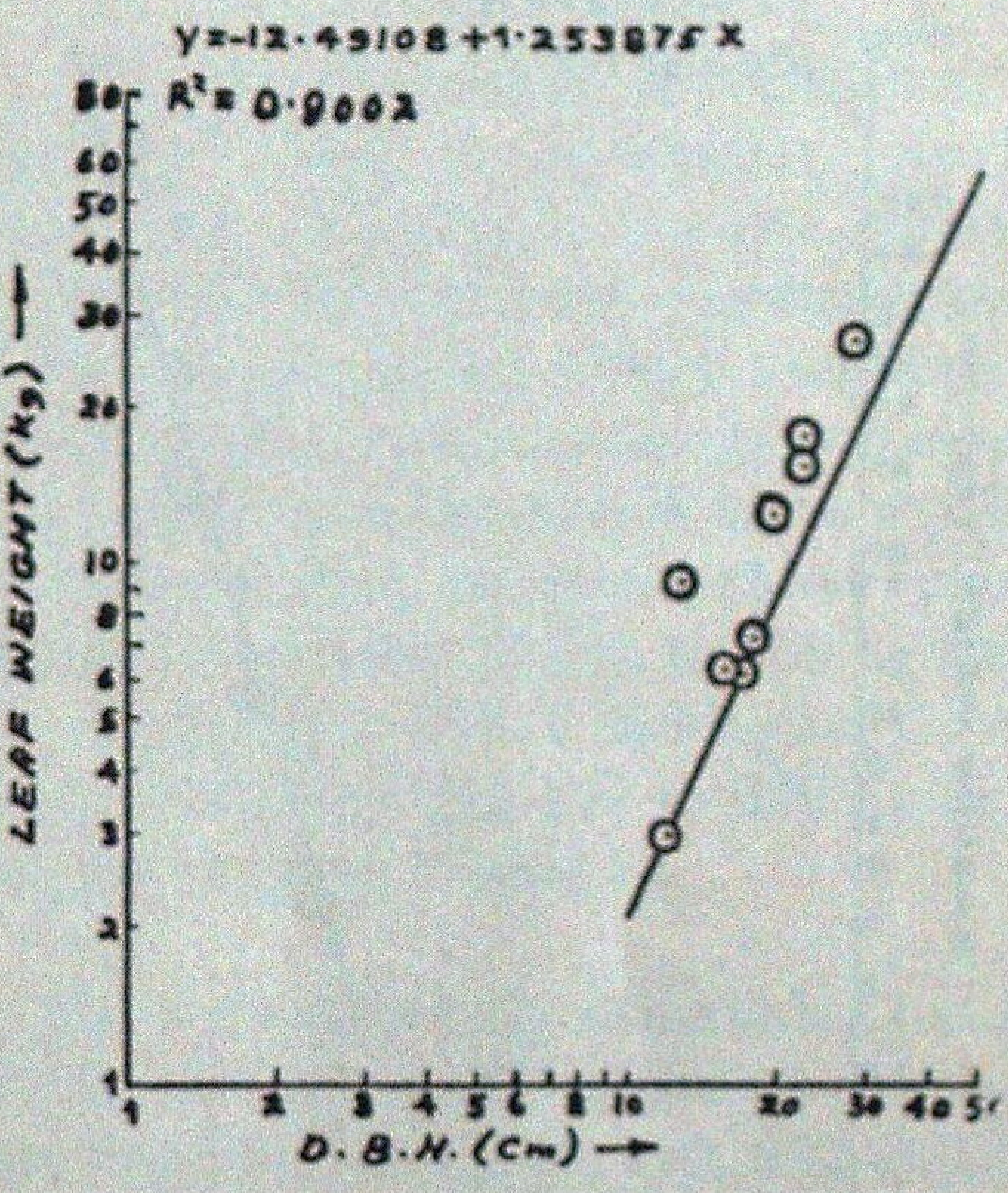
The actual figures of dry weight of different biomass components were plotted separately on log-log graph paper against DBH and above mentioned regression

Fig. 1



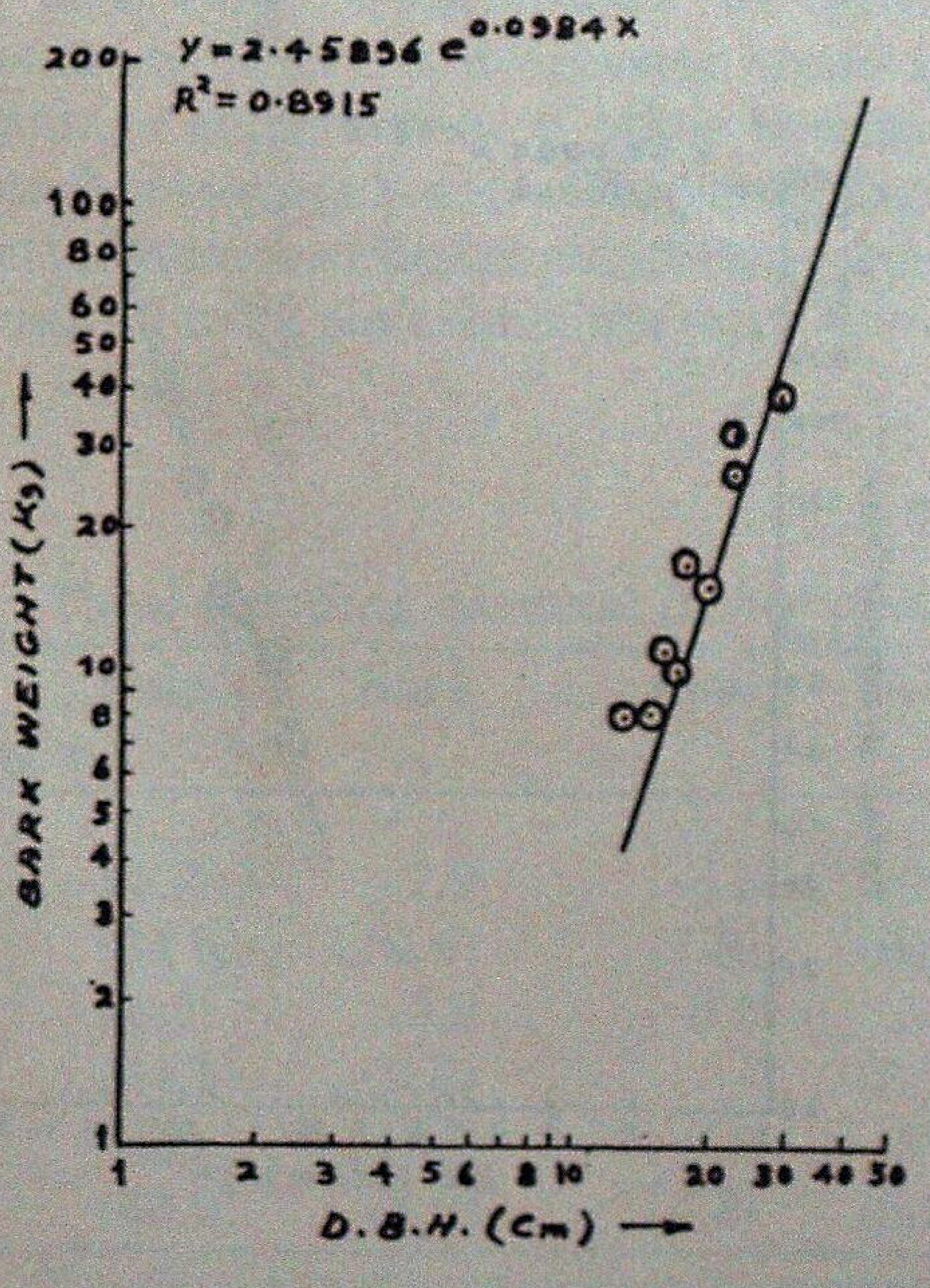
Bole weight/DBH

Fig. 3



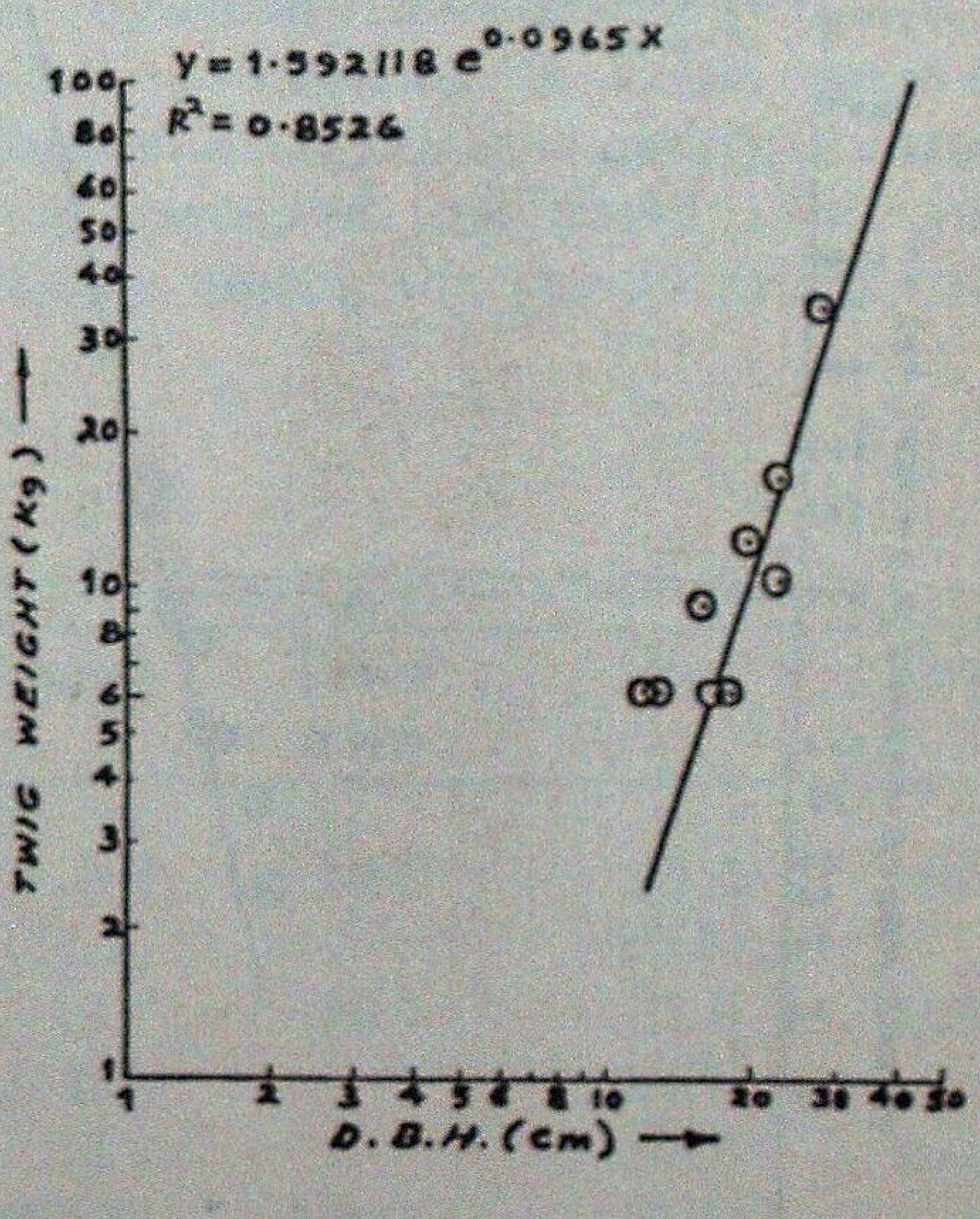
Leaf weight/DBH

Fig. 2



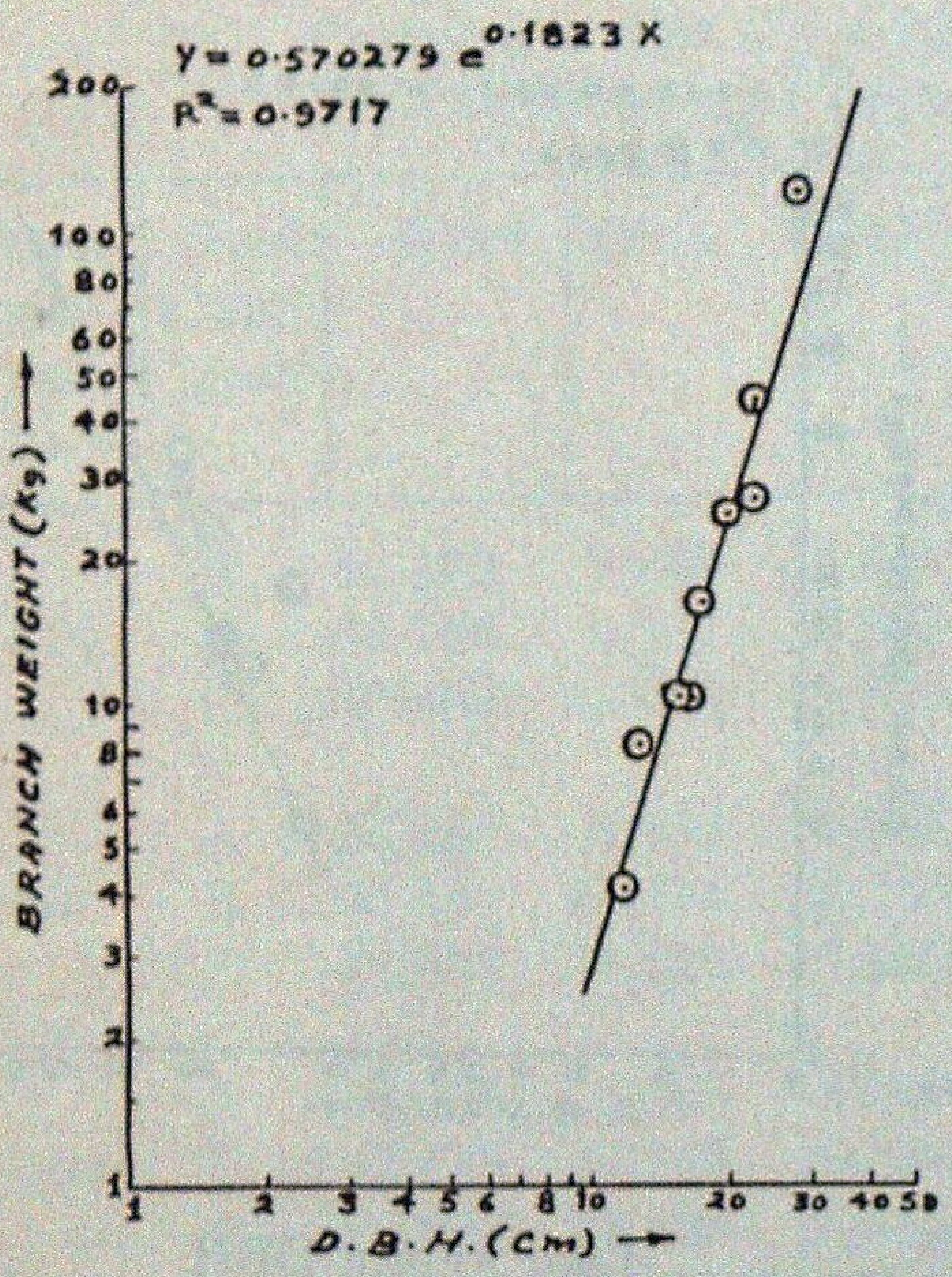
Bark weight/DBH

Fig. 4



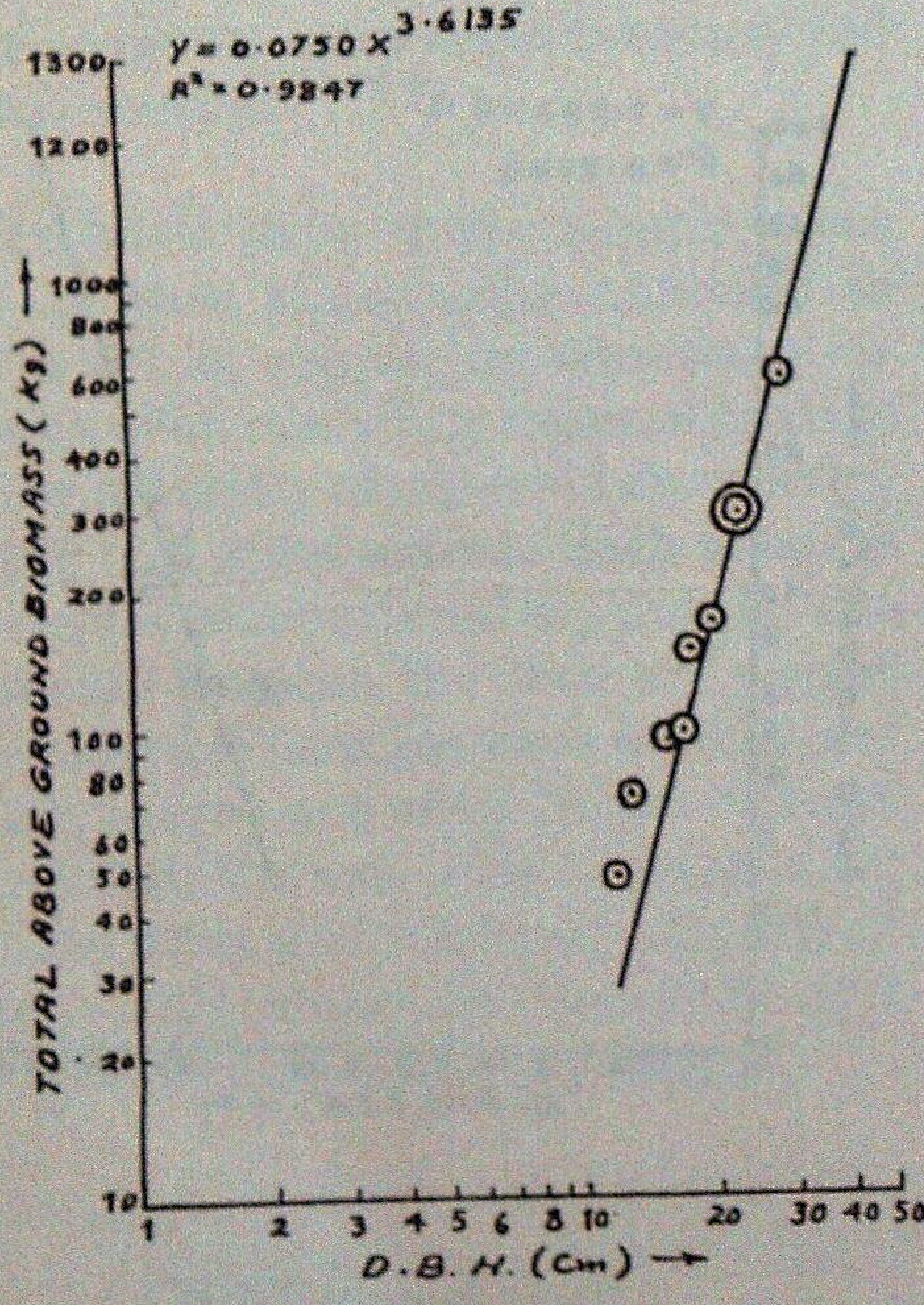
Twig weight/DBH

Fig. 5



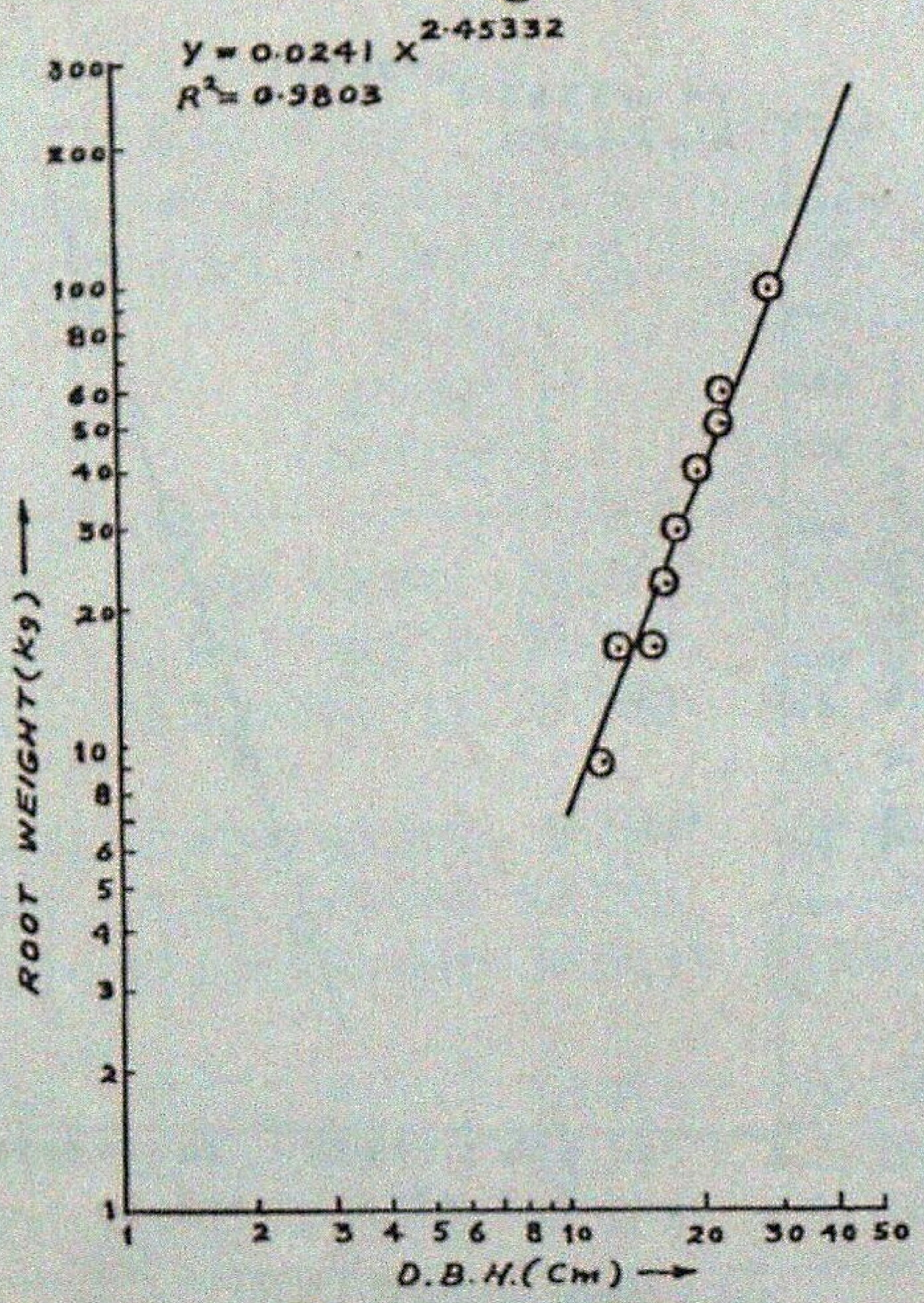
Branch weight/DBH

Fig. 6



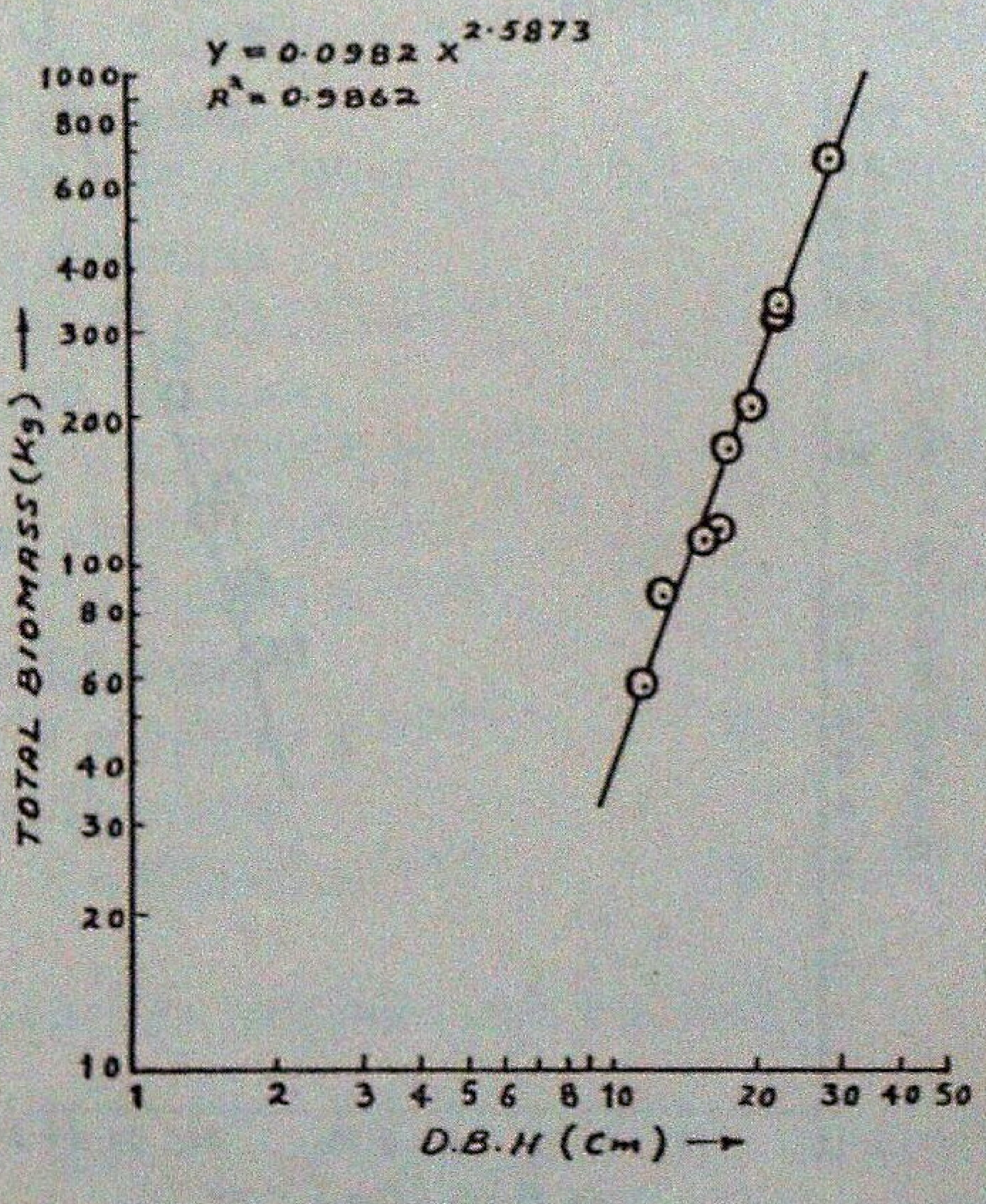
Total above-ground biomass/DBH

Fig. 7



Root weight/DBH

Fig. 8



Total biomass/DBH

equations fitted (Fig. 1 to 8). Highly significant correlations confirm that DBH can be used as reliable parameter for prediction purposes.

Biomass

The accumulation of organic matter in these stands on an unit area (t/ha) has been derived from regression on diameter at breast height (d.b.h.) and is given in Table 2. The above ground biomass of these plantation is in the order of 74.6, 90.7 and 164.1 t/ha at the age of 10, 20 and 30 years respectively, showing the growth of biomass with age. Similar trend of increasing biomass with increasing age was observed for all the biomass components. The above ground biomass increases more than twice from 74.6 t/ha at the age of 10 years to 164.1 t/ha at 30 years of age. With regard to the percentage contribution of different biomass components to the above ground biomass, bole contributes the maximum, 60 to 65 per cent and rest is attributed to other components. There is decreasing trend is percentage contribution of other biomass components except branch. The percentage of root biomass in different plantation varies between 17 to 21 per cent of the total above ground biomass.

Nutrient Distribution

The concentration of nutrients in different tree components varies considerably. Though in general, highest concentration of nutrients was observed in leaf, the accumulation of N, P and Mg was observed in bole and maximum Ca was held up in bark and roots and K in roots. The nutrients accumulated in the above ground biomass range from N 225 to 359 kg/ha; P 14 to 28 kg/ha; K 152 to 265 kg/ha; Ca 426 to 748 kg/ha; and Mg 107 to 229 kg/ha in these plantations (Table 3).

Harvesting of only utilizable biomass (148 t/ha) at the age of 30 years would result in the removal of 247, 41, 170, 632 and 198 kg/ha of N, P, K, Ca and Mg respectively.

Discussion

It is evident from the data that there is much variation in the diameter (dbh) within the same plantations. The mean tree of the highest diameter class is nearly two times the diameter of the lowest class, such variation among the population has also

Table 2

Total standing biomass (t/ha) of different aged Tectona grandis plantations

Age biomass	Bole	Bark	Leaf	Twig	Branch	Total a.g.b	Root	Total
10	48.2	7.9	5.2	5.0	8.3	74.6	15.4	90.0
	(64.6)	(10.6)	(7.0)	(6.7)	(11.1)		(20.6)	
20	58.1	8.9	5.5	5.5	12.7	90.7	17.9	108.6
	(64.1)	(9.8)		(6.1)	(14.0)		(19.7)	
30	98.8	13.9	7.8	8.5	35.1		28.5	192.6
	(60.2)	(8.5)	(4.8)	(5.2)	(21.4)	164.1	(17.4)	

Note - Figures in parenthesis indicate the percentage of the total above ground biomass.

Table 3

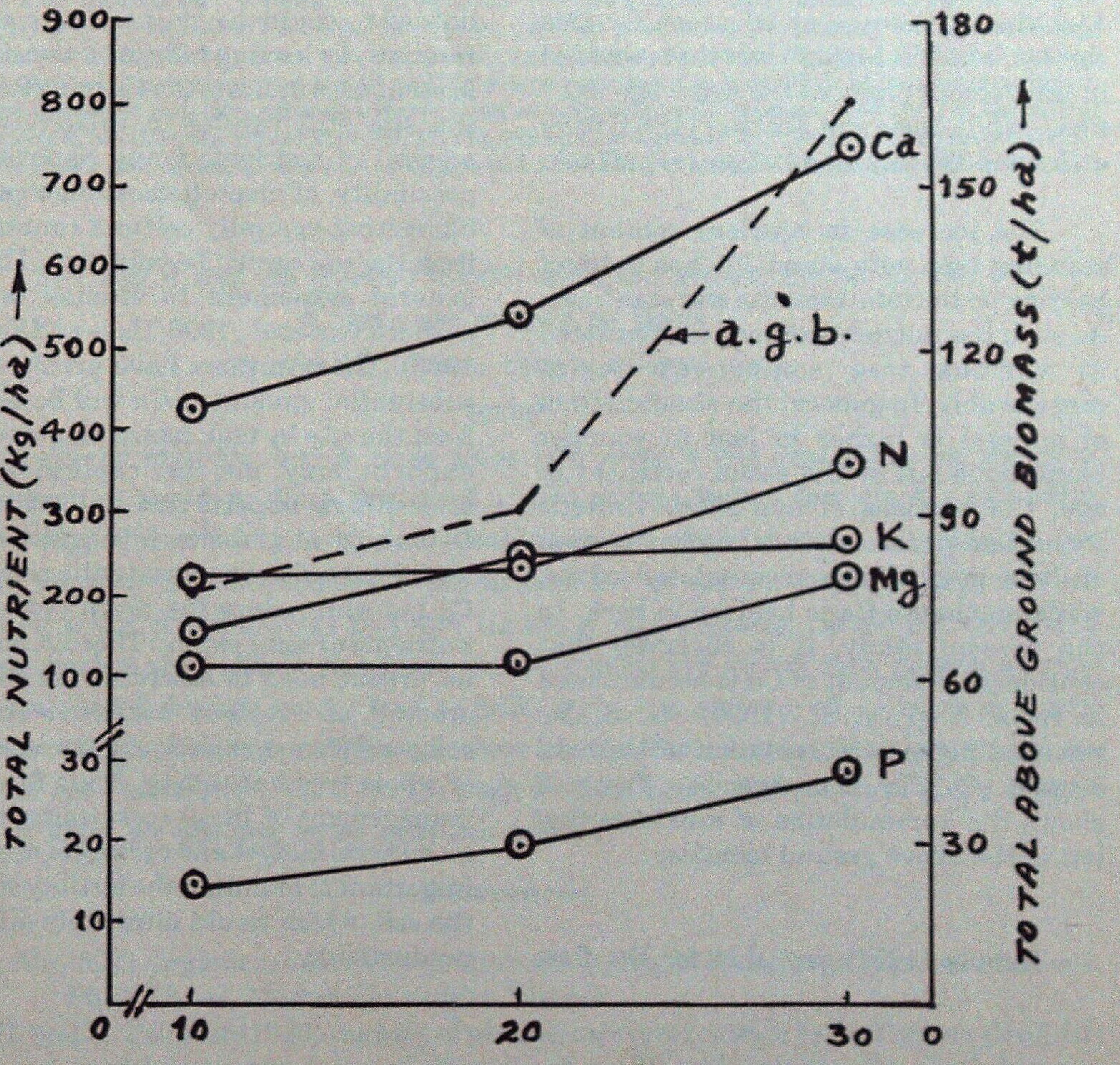
Mineral contents in biomass components (kg/ha)

Nutrients		Age (Years)		
		10	20	30
N	Bole	92.87	91.52	175.97
	Bark	27.51	35.56	28.26
	Leaf	59.54	64.39	111.32
	Twig	16.79	16.89	32.60
	Branch	28.26	19.53	43.00
	Total a.g.b.	224.97	227.89	358.55
	Root	47.46	72.32	63.57
	Total	272.43	300.21	422.12
P	Bole	4.04	10.17	18.52
	Bark	2.45	2.88	3.53
	Leaf	2.63	1.31	2.18
	Twig	1.33	0.89	2.17
	Branch	3.14	4.11	2.05
	Total a.g.b.	13.59	19.36	28.45
	Root	4.42	6.43	12.22
	Total	18.01	25.79	40.67
K	Bole	36.34	61.02	46.31
	Bark	33.62	63.43	51.80
	Leaf	35.02	48.73	61.12
	Twig	24.75	22.23	34.05
	Branch	22.76	37.01	71.67
	Total a.g.b.	152.49	232.42	264.95
	Root	83.89	144.64	190.70
	Total	236.38	377.06	455.65
Ca	Bole	80.76	101.69	185.23
	Bark	195.62	320.05	337.89
	Leaf	61.29	14.36	82.22
	Twig	51.26	38.67	34.05
	Branch	36.89	61.68	108.53
	Total a.g.b.	425.82	536.45	747.92
	Root	143.49	176.78	244.49
	Total	569.31	713.23	992.41
Mg	Bole	56.53	71.19	157.45
	Bark	17.12	7.69	8.24
	Leaf	14.01	13.92	20.37
	Twig	8.84	7.11	10.14
	Branch	10.99	13.36	32.76
	Total a.g.b.	107.49	113.27	228.96
	Root	39.74	57.86	58.68
	Total	147.23	171.13	287.64

been reported earlier in this region, *Eucalyptus* hybrid (George, 1977); *Populus deltoides* (Tandon *et al*., 1991).

Keeping in view the contribution of diameter and height to the component plant parts and total biomass, linear relationship was established, using d.b.h. as prediction variable. Though D^2H may slightly improve the prediction, but where the trees are sampled from the same locality and for the same species, under such uniform condition, the relationship between d.b.h. and height is very close and inclusion of height does not contribute significantly to regression (Schonan and Boden, 1981). In the present study, the regression equation (equation 1 to 8), using d.b.h. as independent variable, show a highly significant correlation. The relationship for leaf and twig are slightly weaker. This may be attributed to biotic disturbances, such as lopping etc. Thus

Fig. 9



Total retention of nutrients (kg/ha) accumulated in Total above-ground biomass (t/ha) d.b.h. alone can safely be used for prediction of biomass of this species in this region, as reasonably precise value of biomass can be obtained with this parameter.

The total standing biomass increases with increasing age from 74.6 t/ha (10 years) to 164.1 t/ha (30 years). Kaul *et al.* (1979) estimated total above ground biomass 130 t/ha at the age of 38 years. Negi *et al.*, (1990) in their comparative study on Teak and Gamar carried out in Tripura estimated 114 t/ha at the age of 20 years for this species, which is higher than that recorded in the present study at the same age (90.7 t/ha). While Hase and Foelster (1983) have estimated 398 t/ha for a mature crop of teak.

The increase in nutrient content of standing crop with stand age has a direct bearing on the total biomass and stand age. As such the nutrient content accumulated in various tree component varies considerably. In general the accumulation of mineral is higher in leaf in younger plantations but as the stand increases in age, the biomass of non-photosynthetic components increases and the major portion of all the nutrients are accumulated in bole, while maximum Ca is held up in bark. In the present study, it is observed that considerable amount of Ca is accumulated in roots, Negi *et al.* (1990) have also reported higher accumulation of Calcium content (Ca) in this species. Figure 9 shows the accumulation of nutrients (kg/ha) in the above ground biomass.

Rannie (1955) probably for the first time, has drawn attention towards very considerable amount of nutrients immobilized in the crop and has questioned the ability of poorer soils to supply over prolonged period the nutrients required to maintain continuous timber production. The nutrient elements are lost from the site in a number of ways, the greatest loss being though tree removal. The perusal of the present data shows that a considerable amount of nutrients are tied up in the aerial organs of the tree (Fig. 9), some advantage, however, could be gained over several rotations by leaving foliage on the site. The present data indicate that leaving foliage at the site still results in relatively large amount of nutrients being removed. The possibility of depletion of nutrients on harvesting specially calcium content (Ca) from the soil cannot be ruled out. This is in general agreement to studies reported earlier (Negi *et al.*, 1990; Hase and Foelster, 1983). These authors have predicted that substantial amount of Ca will be removed from the site by teak harvesting and these exports may not be replenished by atmospheric imports and soil weathering. Debarking at the site is suggested. This would not only compensate the removal of Ca but also reduce the drain of the other nutrients to some extent. There is, however, an urgent need to establish the rate and amount of various nutrients that are removed from a variety of sites as a result of whole tree harvesting. Thus for proper management of these ecosystems, studies on mineral budget and cycling of mineral is important to maintain the fertility status of the soil, which would ultimately affect the productivity.

Acknowledgements

The authors are thankful to Shri Rajesh Kumar, Division of Facility, Forest Research Institute, Dehra Dun and his staff for statistically analysing the data. The invaluable help rendered by the State Forest Department, U.P. specially the Divisional Forest Officers, Tarai Central and Haldwani Divisions by providing necessary facilities during collection of field data is also gratefully acknowledged.

SUMMARY

Estimates of component wise dry matter production and nutrient distribution of 10, 20 and 30 years old plantations of Teak (*Tectona grandis* Linn. f) have been discussed. Linear regresssion analysis was carried out. Among the prediction variables tried, DBH alone was found to give reasonably precise values of biomass and can be used for prediction purposes. The total standing biomass of these stands increases with increasing age and diameter from 74.5 t/ha (10 years) to 164.1 t/ha (30 years). Maximum amount of N, P and Mg was accumulated in hole while higher accumulation of Ca was observed in bark and roots. Harvesting of only utilisable biomass (148 t/ha) at the age of 30 years would result in the removal of 247, 41, 170, 632 and 198 kg/ha of N, P, K, Ca and Mg respectively. Defoliating and debarking at the site is suggested to reduce the drain of nutrients from the soil especially Ca contents.

उत्तर प्रदेश में तराई क्षेत्र के सागौंन (*टैक्टोना ग्रांडिस* लि० वत्स) के कम उम्र रोप-वनों में जैवपुंज और पोष्याहारों का वितरण

एम०एस० नेगी, वी०एन० टण्डन व एच०एस० रावत

सारांश

सागौन (*टैक्टोना ग्रांडिस* लि० वत्स) के 10, 20 और 30 वर्षीय रोपवनों में शुष्क पदार्थ उत्पादन और पोष्याहार के अवयववार वितरण के अनुमानों का विवेचन किया गया है । रेखीय प्रतीपायन विश्लेषण किया गया है । इसमें परीक्षित भविष्यानुमान विचरों में केवल वक्षोच्चा पर व्यास ही संतोषप्रद सुतथ्यता से जैवपुंज की अर्हाओं का अनुमान देता पाया गया है और उसे भविष्य कथन के लिये उपयोग में लाया जा सकता है । इस खड़े वनों के वृक्षों का जैवपुंज रोपवन की उम्र और व्यास में वृद्धि के साथ-साथ 74.5 टन/हेक्टेयर (10 वर्ष) से 164.1 टन/हेक्टेयर (30 वर्ष) तक बढ़ता जाता है । नाइट्रोजन, फास्फोरस और मैगनीशियम की अधिकतम मात्रा तने में एकत्रित होती पाई गयी जबकि कैलशियम का अधिक जमाव छाल और जड़ो में होता पाया गया है । केवल उपयोजनीय जैवपुंज (148 टन/हेक्ट०) की ३० वर्ष की उम्र में कटाई करने का परिणाम नाइट्रोजन, फास्फोरस, पोटाशियम, कैलशियम और मैगनीशियम का क्रमशः 247, 41, 170, 632 और 198 क्रिग्रा/हेक्टेयर मात्रा निकलना होगा । मृदा से पोष्याहार निकल कर जाना विशेषकर कैलशियम, घटाने के लिए काटने की जगह पर ही पत्तियाँ और छाल उतार देने का सुझाव दिया गया है ।

References

George, M. (1977). Organic productivity and mineral cycling in *Eucalyptus* hybrid plantations. *Ph.D Thesis*, Meerut University, Meerut.

Hase, H. and H. Foelster (1983). Impact of plantation Forestry with teak (*Tectona Grandis*) on the nutrients status of alluvial soils in West Venezuela. *For. Ecol. Manage* **6** (1) : 35-57.

Kaul, O.N., D.C. Sharma, V.N. Tandon and P.B.L. Srivastava (1979). Organic matter and plant nutrients in a teak (*Tectona grandis*) plantation. *Indian Forester,* **105** (8) : 573-582.

Negi, J.D.S., V.K. Bahuguna and D.C. Sharma (1990). Biomass production and distribution of nutrients in 20 years old teak (*Tectona grandis*) and Gamar (*Gmelina arborea*) plantation in Tripura. *India Forester*, **116** (9) : 681-686.

Ovington, J.D., W.G. Forrest and J.E. Armstrong (1967). Tree biomass estimation. *Symp. Pri. Pro. & Min. Cycling in Natural Ecosystem*, Maine : 4-31.

Rannie, P.J. (1955). The uptake of nutrients by Mature Forest Growth. *Plant & Soil* **VII** : 49-95.

Schonan, A.P.G. and D.I. Boden (1981). Preliminary biomass studies in young *Eucalyptus*. *XVII IUFRO World Congress*, Kyoto, Japan : 51-58.

Tandon, V.N., M.C. Pande, H.S. Rawat and D.C. Sharma (1991). Organic productivity and mineral cycling in plantations of *Populus deltoides* in Tarai Region of Uttar Pradesh. *Indian Forester*, **117** (8) : 596-608.

Tewari, D.N. (1992). *A Monograph on Teak* (*Tectona grandis* Linn. f) Int. Book Distributors, Dehra Dun.

Snippets ENVIRONMENT

The National Particle-board Assoc. has pledged $ 150,000 over 3 years to sponsor a program of environmental communications and advertising. The campaign, part of the Wood Works campaign, will be organized by the Wood Product Promotion Council. The particleboard industry is based on use of residues and has invested extensively in research on issues related to the environment.

Source : *Forest Products Journal,* Vol. 45, No. 5

EFFECTS OF CULLING ON PLANTING STOCK PRODUCTION IN TEAK NURSERY

K. SUBRAMANIAN*, V.M. GADBAIL**, N. RAMBABU*** AND MOHAN JHA****

Forest Development Corporation of Maharashtra Ltd.,
Nagpur (Maharashtra)

Introduction

One of the most important objective of the Forest Development Corporation Ltd., Maharashtra (FDCM Ltd.) is to convert "potentially productive area" into "productive area" using the better planting stock of valuable species (Anon., 1977). Teak (*Tectona grandis* Linn.) being the most valuable species of Maharashtra forests, it is decided to under take around 50,000 ha of teak plantation under the production model of World Bank aided Maharashtra Forestry Project during the 6 years of project period. Good nursery stock is the prerequisite for maximising production in any plantation. The basic goal of having uniform quality seedlings is to achieve the best growth possible and have the highest amount of desired output (Anon., 1993).

Phenotype is the result of the genotypes response to a particular type of environment. In case of teak where stump (Root-shoot cutting) planting is the common practice in most parts of the country, the collar diameter is used as the major criteria for grading seedlings at nursery. In Maharashtra, teak stumps are graded after uprooting and before planting into three grades viz. A, B and C (Sardar and Subramanian, 1991). And mostly A and B grade stumps are used for planting and C grade stumps are discarded. However, keeping the 'C'- grade seedlings on nursery beds throughout the growing season have adverse effect on growth of other seedlings on bed. Seedlings which are not required for planting if kept on bed uses nutrition and moisture from bed and increases the root competition, which in turn retards the growth of better seedlings also. In general, quality of seedlings increases with a corresponding decrease in growing density. Because phenotype partly depends on genotype, directional selection by culling produces better genotype mixture (Campbell and Sorensen, 1984).

In the present paper the effects of culling (removal of inferior seedlings) on the production of quality teak seedlings are discussed.

Materials and Methods

Culling experiments were carried out at Wada Nursery in Thane District of Maharashtra. In the above teak nursery 10 beds each were selected in three different blocks. Then in each block 5 alternate beds were given the culling treatment and 5 beds were kept unculled (control). In each block alternate beds were culled keeping rest of the bed unculled so as to avoid any local influence of soil variation. Hence in total 15 beds were culled and 15 beds were kept unculled for comparison.

---

* Regional Manager, Nursery Development Unit; ** Assistant Manager, Seed Unit,
*** Divisional Manager, Seed Unit; **** Divisional Manager, Plantation Inventory Unit.

In each bed, 2.5 kg of treated teak seeds were sown in the last week of March 1993. The beds were irrigated through sprinkler system from 1st April, 1993 to 15th June, 1993. The culling operations were carried out in the last week of June 1993, in the last week of August 1993, and in the first week of October. Weedings were carried out four times to prevent weed growth. In the nursery beds, mixture of B.H.C., Thimet 10 G (1:1) were given uniformly during June, July and August, 1993.

In the culling operation, seedlings showing poor growth and infection with insect or fungus were removed. At the same time congestion among seedlings were removed in such a way to retain best seedlings from the group.

In the month of June 1994, a sample plot of 1 m x 1 m was randomly laid out in each bed. From each sample plot seedlings were uprooted and measurements for collar girth. root length and shoot length were recorded. Stumps were graded on the basis of collar girth as follows :

Girth Class (cm) *Grade*
5-6 = A Grade
4-6 = B Grade
3-4 = C Grade
2-3 = D Grade

The availability of A grade seedlings and coefficient of variation are calculated to assess the quality of planting stock.

Results and Discussion

As a result of selective culling number of available seedlings are reduced from 935 per bed to 615 per bed (66% saved) (Table 1). On careful analysis of available planting stock, it is evident that number of 'A' grade seedlings are 40.66% in culled bed as compared to 18.08% in unculled bed. (Table 1). Both unculled and culled beds have almost same percentage of 'B' grade seedlings. However, the unculled beds have greater percentage of 'C' and 'D' grade seedlings as compared to culled beds.

Table 1

Planting stock available per bed

Grade	Unculled		Culled	
	No.of stump	Total(%)	No. of stump	Total (%)
A	169	18.08	250	40.66
B	326	34.87	227	36.91
C	335	37.97	115	18.70
D	85	9.08	23	3.73
Total	935	100.00	615	100.00

Therefore, culling has a positive effect on production of 'A' grade seedlings. However, by favouring more directional selection, using intensive culling, can produce more 'A' grade seedlings. In case of normal culling, around 65 to 75% of seedlings normally are saved. If selection intensities are increased by savings around 40% of the original lot, mean genotype values can be shifted twice as far as normal culling (Campbell and Sorensen,1984).

Collar Girth : Table 2 shows average collar girth of seedlings in unculled and culled beds. The unculled beds show greater coefficient of variation than unculled beds in respect of collar girth. This indicates that culling helps in production of uniform seedlings with comparatively less variation. Hence, culling is definitely useful in producing better quality of uniform seedlings by minimising variation within the planting stock.

Table 2

Coefficient of Variation in Culled and Unculled seedlings
(Collar Girth)

	Unculled	Culled
Mean (cm)	3.81	4.33
Standard Deviation	1.93	1.15
Coefficient of Variation	50.71	26.64

Root Length : Teak seedlings raised on beds, after uprooting are converted into stumps by keeping 5 cm of shoot and about 25 to 30 cm of root portion, before planting in field. In view of the above facts, root length which is an important part of stump were also studied. Results of effects of culling on root length is presented in Table 3. It is evident from the result that culled bed produces more number of seedlings in higher root length i.e. length class 21 to 30 cm and 31-40 cm. However, in lower length class, less number of seedlings are produced in culled beds. Hence, culling practice has also effected the root length in teak seedlings in a positive way.

Shoot Length : Table 4 shows the result of length class wise distribution of shoot length. It is clear that unculled bed have more number of seedlings in higher length class. But majority of seedlings are in length class 21-40 cm. Hence, there is not much of difference in the shoot length distribution in culled and unculled beds.

Table 3

Root length in culled and unculled beds

Length Class (cm)	Seedlings (%)	
	Unculled	Culled
0-10	14.5	11
11-20	46	35
21-30	36	44
31-40	35	10

Table 4

Shoot length in culled and unculled beds

Length Class (cm)	Seedlings (%)	
	Unculled	Culled
0-20	1	2
21-40	93	82
41-60	6	16

Conclusion

For improving the productivity of plantation, quality seed and planting stock play a vital role. It is evident from the culling experiment that better quality of seedlings can be produced by improved nursery practices. Culling is one of such nursery practices which helps in directional selection of planting stock. Culling helps in producing phenotypically better quality seedlings with uniformity. No doubt effect of better quality planting stock on productivity of a plantation needs further study. However, it has been proved that better planting stock have significant effect on survival and growth rate in conifers (Campbell and Sorensen, 1984).

Acknowledgements

The authors are thankful to Dr. A.G. Raddi, IFS, Chief Conservator of Forests, Maharashtra Forestry Project Co-ordination Unit, Pune who was the moving spirit in conducting this culling experiment in Teak nursery at Wada. Thanks are also due to Shri M.G. Gogate, Conservator of Forests, Research Circle, Pune who frequently interacted on this subject in different stages and to the officials and staff of the Divisional Manager, Thane Project Division, F.D.C.M. Ltd., Thane for organising experiment as per the project outlines.

SUMMARY

This paper deals with the effect of culling on production on teak planting stock. Culling produces uniform and better quality seedlings.

सागौन रोपणी से लगाने लायक पौधे तैयार करने पर निकृष्ट-चयन का प्रभाव

के० सुब्रामनियन वी०एम० गडबैल, एन० रामबाबू व मोहन झा

सारांश

इस अभिपत्र में सागौन के रोपण योग्य पौधे तैयार करने पर निकृष्ट - चयन के प्रभाव का विवेचन है । घटिया पौधे निकालते जाने से एक समान और उत्तमकोटि के पौधे तैयार होते हैं ।

References

Anon (1977). Project Report, FDCM Ltd.

Anon (1993). *Technical Bulletin*, Forests & Forestry, World Bank/Agrnr - No.2, April - 1993.

Campbell, K. and F.C. Sorensen (1984). *Forest Nursery Manual* : *Production of bare-root seedlings*. (Eds M.L. Duryea and D. Landis). Martinus Nijholf Dr. W. Junk Publishers. Boston p 183-190.

Sardar, M.G. and K. Subramanian (1991). Modern Teak Nursery Management in FDCM Ltd. *Proc Int. Teak Symposium* (2-4 December).

USE OF COPPICE SHOOTS IN SEED PRODUCTION AREAS OF TEAK : A NEW CONCEPT

M.S. RAWAT, D.P. UNIYAL AND C.J.S.K. EMMANUEL

Division of Genetics and Tree Propagation,
Forest Research Institute, Dehra Dun (India).

Introduction

In the seminar on "Vegetative Propagation" held in July, 1989 at the Institute of Forest Genetics and Tree Breeding, Coimbatore Dr. R.V. Singh, the then Director General of ICFRE, had in his keynote address emphasised the need of giving due consideration and importance to the coppicing ability of various tree species also as a method of vegetative propagation and that wherever possible advantage of this method should be taken for further propagation as an important tool for tree improvement.

Rao (1953) has given a comprehensive list of plants belonging to 37 families and covering most of the important forestry species, which can be propagated by various vegetative propagation techniques. As per his observations apart from other methods of propagation 68 genera out of 110 and 95 species out of 161 possess specially remarkable ability to reproduce by coppicing. Teak, *Acacia*, Shisham and Sandal are a few to mention. In this paper the use of this technique for creating seed production areas of Teak has been explored as follows.

"Teak coppices very well and all coppice shoot originate in one of two ways (1) from callus growth developed inside the bark and situated between the bark and the wood at the edge of the cut surface or (2) from the side of the stool below the cut surface, the shoot appearing through the bark. The former, which may be termed 'callus shoot' are of adventitious origin, while the latter, which may be termed 'side shoots' probably arise from dormant buds".

"Teak coppices and pollards vigorously and sometimes retains the power of coppicing to a considerable size. Mr. Foulkes mentions a tree in North Malabar with a breast height girth of 97 in which when felled produced 22 coppice shoots, and stems with diameter 2 ft. 10 in. to 6 ft. 4 in. which produced 11-13 shoots per stool. The early growth of coppice and pollard shoots is rapid".

Of twelve different species coppiced and pollarded experimentally in 1909 in North Chanda, Central Provinces, Teak showed the most rapid growth both of coppice and pollard shoots (Troup, 1921).

Observations

Coppice shoots flower and fruit abnormally early. Seed from coppice, nine year old, collected in Saugor, Central Provinces and tested by the Forest Botanist at Dehra Dun in 1908 germinated and produced healthy seedlings (Troup, 1921).

Davar (1934) has reported that in Gallapalle reserves of old Bastar State coppice shoots flowered at the age of 4 years and 9 months.

Muniswamy (1986) states "experiences in Andhra Pradesh have shown that some of the trees in the seed production areas have been responding to the opening created by producing more flowers and fruits than what they produced earlier". He further says should we take a risk to coppice such trees and allow them to put forth coppice shoot to bear maximum fruits ? Or is there a way out.

According to Dabral (1991) in Maharashtra the bulk of the seed is collected from second coppice growth and it gives quite satisfactory results in germination and growth and the collection is also less expensive.

Authors had coppiced two 10 year old plants, which had already started flowering and fruiting and pruned, them for next two years to train them to produce well developed and balanced crowns and observed that after three years they produced profuse flowers and fruits. In several other plants also, coppiced after the initiation of flowers, flowering and fruiting was quite satisfactory.

In 1992 an experiment was again carried out taking seed from two sets of 30 year old plants, heavily pollarded and pruned, plants and those which were growing naturally, and it was found that there was no difference in their weight, germination capacity and survival.

Discussion

It has been stated that the quality of the coppice shoots is not as good as the mother tree but this decline is due to the site deterioration (Rawat, 1991) and in no way it effects the genetic characters. After all the plant is reproducing itself by vegetative means only. Hence, it is worthwhile to experiment on large scale on this line. The selected coppice plants after two three prunings can be trained to developed a canopy to bear large number of inflorescences and fruits in the next two to three years. The best time for coppicing or pollarding are reported to be March or September (Troup, 1921).

Conclusion

With the experience gained so far from the Model Seed Orchard and Germplasm Bank of Teak at New Forest it has been observed that coppice growth is as fast as that of grafts in the seed orchard and in the similar way the coppice can also be pruned to develop a well spread and balanced crown and of convenient height also so as to bear more inflorescences and produce more seed and also to make seed collection easier and less expensive. This technique can be adopted for other species also which give good response to coppice growth e.g. *Acacia, Dalbergia, Santalum,* etc. are a few to mention.

SUMMARY

Creation of seed production areas is an important step in the Tree Improvement Programme for the interim supply of superior seed for afforestation till the seed orchards become fully productive. In Teak seed production areas the production of seed is not only insufficient but its collection is also difficult and expensive. Hence a new approach has been suggested, keeping in view the excellent coppicing capacity of Teak, for higher production of seed per tree and making the collection easier and cheaper.

सागौन के बीज उत्पादन क्षेत्रों में स्थूण प्ररोहों का उपयोग : एक नई दृष्टि

एम०एस० रावत, डी०पी० उनियाल व सी०जे०एस०के० इम्मेनुएल

सारांश

बीज उद्यानों के पूरी तरह से उत्पादक बन जाने से पहले के समय में वनीकरण के लिए उत्तम कोटि का बीज अन्तरिम रूप से उपलब्ध करने के वृक्ष परिष्कार कार्यक्रम में बीज उत्पादक क्षेत्रों को तैयार करना एक महत्वपूर्ण पग है । सागौन के बीज उत्पादक क्षेत्रों का बीज उत्पादन अपर्याप्त होने के अलावा इसे इकट्ठा करना भी कठिन और महंगा पड़ता है, इसलिये वहाँ सागौन के अत्युत्तम स्थूण रूह गुणों को ध्यान में रखते हुए एक नई दृष्टि अपनाने का सुझाव दिया गया है जिससे प्रतिवर्ष बीज का उत्पादन अधिक हो सकता है तथा उसका संग्रह करना सरलतर और अधिक सस्ता भी हो जाएगा ।

References

Dabral, S.L. (1991). *Personal Communication*.

Davar, S.A. (1934). Silviculture and management of Teak by K. Kadambi, *Bull.* **24:** 1972. School of Forestry Stephen F. Austin State University, Texas.

Muniswamy, K.P. (1986). Improved seed production in Andhra Pradesh. *Proc. National Seminar on Forest Tree Seeds*. Organised by Indo Danish Project, FRI. On seed Procurement and Tree Improvement and Andhra Pradesh Forest Department. pp. 25-31.

Rao, H.S. (1953). Vegetative Propagation and Forest Tree Improvement, *Indian Forester,* **79 :** 176-183.

Rawat, B.S. (1991). *Personal Communication*.

Troup, R.S. (1921). *The Silviculture of Indian Trees*. Vol. II pp. 697-769. Clarendon Press, Oxford.

SEWAGE WATER AS POTENTIAL FOR THE TREE GROWTH - A STUDY ON TEAK, (*TECTONA GRANDIS*) PLANTATION

M.G. GOGATE*, U.M. FAROOQUI** AND V.S. JOSHI***

Introduction

The increase in the human population in the Urban areas and the rapid pace of industrialisation have led to dramatic increase in the quantity of waste/sewage water released into streams and lakes, over recent years. These discharges are the most common sources of pollution. But such sewage/waste water, can be used for irrigating the tree crops thereby minimising environmental pollution, and utilising its mineral potentials as well.

Forest tree cultivation with sewage

In India, private farmers generally grow vegetable crops of all kinds in the sewage water farms (Misra and Srivastava, 1990). But in such farms along with beneficial nutrients, some toxic metals such as Cd, Cr, Cu, Zn and Pb also get introduced in the food chain which might have toxic effects on animals including human beings (Misra and Srivastava, 1990). However, in forestry crops wherein the end product is wood (non edible), the possibility of health hazards is almost ruled out.

Pinus radiata and a number of Eucalypt species have been successfully grown by utilization of the waste waters (Cromer, 1980; Edgar and Stewart, 1978). A study undertaken by Central Soil Salinity Research Institute, Karnal (Anon., 1990) had shown that forestry crops such as *Eucalyptus* hybrid (*E. tereticornis),* Leucaena (*Leucaena leucocephala)* and Poplar (*Populus* spp.) can be grown successfully by using raw sewage water. Amongst the forestry crops, Teak (*Tectona grandis*) had shown early boosts in the growth when irrigated (Joshi and Farooqui, 1991). In the present study teak plantations raised by one of the progressive farmers near Dhule in Maharashtra are evaluated and future prospects of using sewage water as potential for irrigation are discussed.

Case Study of Irrigated Teak in Dhule

Dhule is situated between Longitude 75°20' East and Latitude 21°10' North, falls under Western Maharashtra Dry (Scarcity) zone. The average annual rainfall is 675 mm. The rainy months are from June to September and climate is extreme i.e. maximum temperature 46.7°C and minimum 6°C. The soil of the tract is generally black loam (Khisty, 1964).

During the year 1987, Shri Dwarkadas Agarwal raised teak plantation on his farm at Dhule at a spacement of 2 m x 2 m covering an area of 1.5 ha on an experimental basis. The area can be divided into five blocks viz A1, A2, A3, B1 and B2. The number of plants and various treatment given to the plot are shown vide Figure 1 and Table 1. The blocks A1, A2 and B2 were channel irrigated with the untreated sewage water (SW) once in twenty days. A1 was thinned in 1991 (SWT) and B2 was supplemented with earthworm castings (SWEC). The blocks A3 and B1 were irrigated with the well water once in twenty days by channel (WW).

---

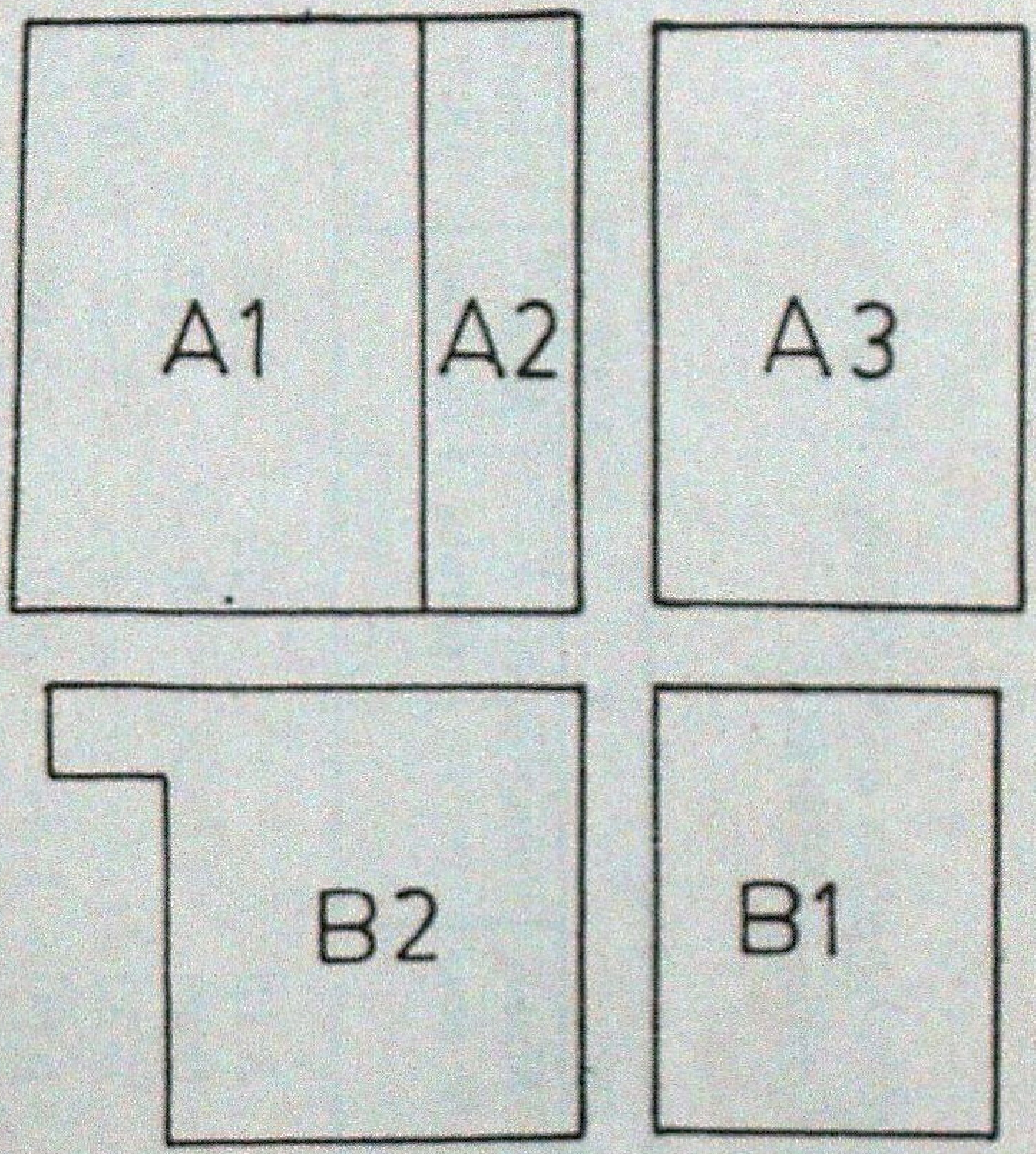
* Conservator of Forests (Research), Pune (Maharashtra)

** Asstt. Forest Utilisation Officer, O/o the Principal Chief Conservator of Forests, Nagpur (Maharashtra)

*** Divisional Forest Officer (Research), Pune (Maharashtra)

In the block A1, out of 936 stumps planted, 413 plants were thinned by removing alternate row during the third year in 1991, thereby increasing the spacement to 4 m x 2 m. The observations in the form of height, girth and survival per cent were recorded separately in the aforesaid blocks in 1991 and survival per cent was recorded one year thereafter. The results were analysed statistically by using ANOVA test.

Fig. 1



Experiment Layout

Index :
I. Sewage Water (SW)
A1 - Thinned (SW)
A2 - (SW)
B2 - Earthworm Castings (SWEC)
II. Well Water (WW)
a3+b1 - (WW)

Table 1

Number of plants in each treatment and survival in 1991, 1992 and 1994.

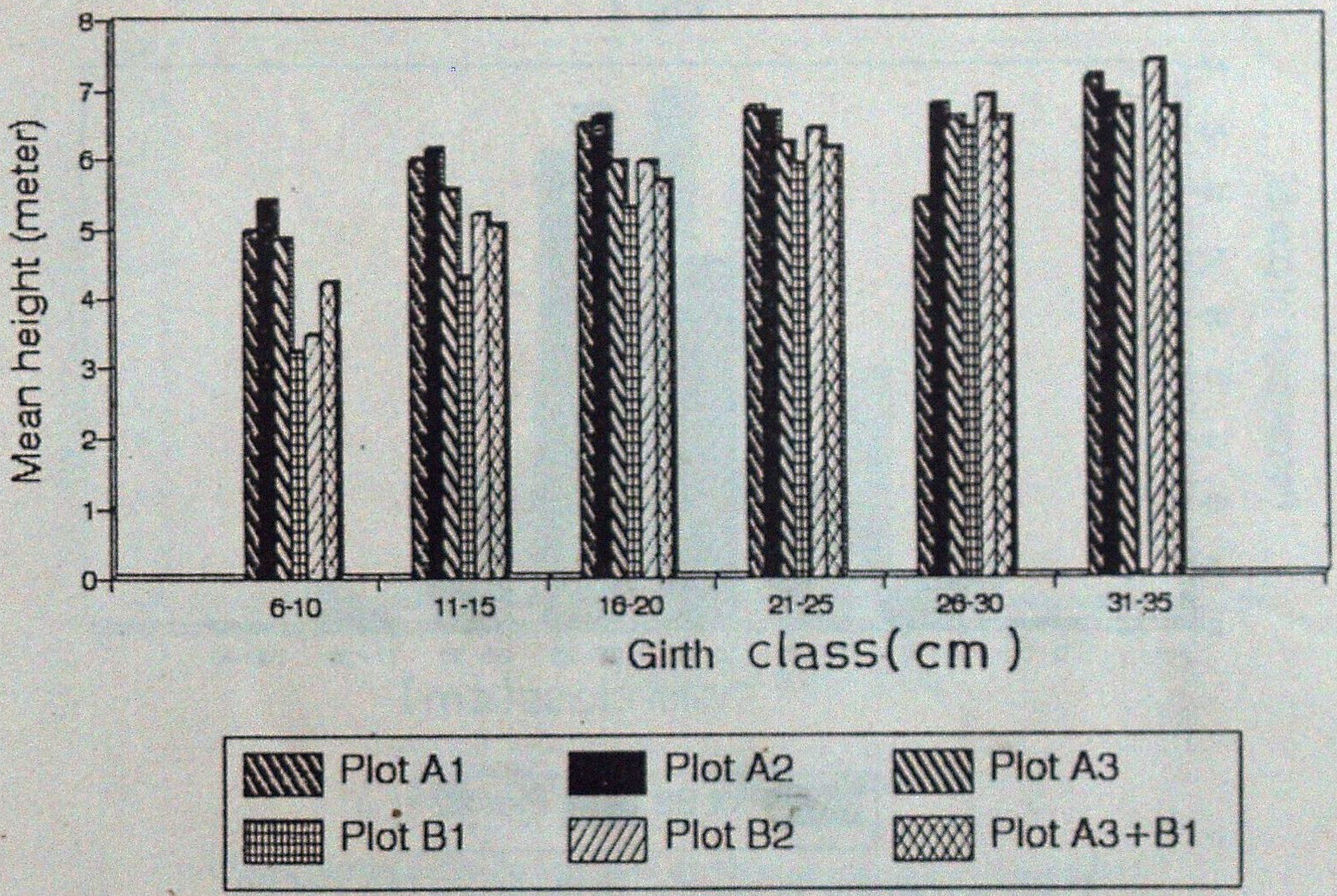
Plot No/Treatment	Total planted in 1987	Total thinned in 1991	Obs. recorded in '91		Obs. recorded in '92		Obs. recorded in '94	
			No. of Surviving plants	Mortality since '87 (%)	Surviving plants	Mortality since '91 (%)	Surviving plants	Mortality since 92 (%)
Sewage Water (SW)								
A1/Thinned (SWT)	936	413	476	8.98	417	12.39	408	2.16
A2/(SW)	507	-	454	10.45	289	36.34	288	-
B2/Earth-worm Castings (SWEC)	881	-	836	5.10	681	18.54	574	15.12
Well Water (WW)								
A3+B1/(WW)	1476	-	1338	9.34	1189	11.14	1096	7.82

Table 2

Comparative height, girth, total tree volume, volume per ha, MAI in different plots with Sewage Water (SW), Well Water (WW) and Sewage water + Earthworm Castings (SWEC).

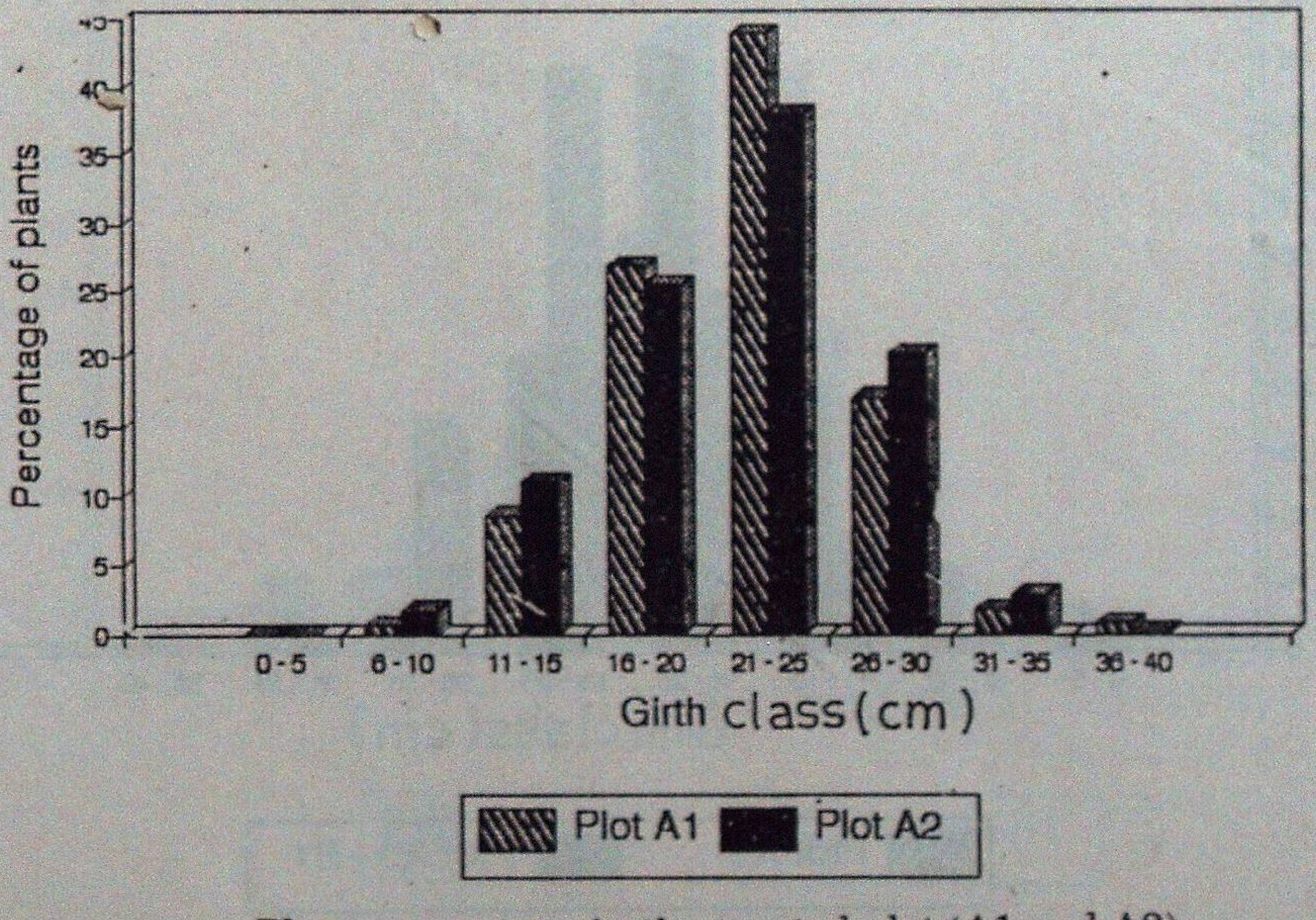
Girth class (cm)	Plot A1			Plot A1			Plot B2			Plot A3 + B1		
	No. of plants	Mean ht. (m)	Volume (m^3)	No. of plants	Mean ht. (m)	Volume (m^3)	No. of plants	Mean ht. (m)	Volume (m^3)	No. of plants	Mean ht. (m)	Volume (m^3)
0-5	0	-	-	0	-	-	2	3.15	-	40	2.25	-
6-10	3	4.97	-	8	5.43	-	28	3.49	-	83	4.22	-
11-15	41	6.01	0.163	50	6.13	-	98	5.22	-	274	5.07	0.517
16-20	128	6.52	0.862	116	6.61	0.729	247	5.96	1.347	609	5.69	2.923
21-25	209	6.72	2.220	173	6.68	1.820	349	6.43	3.411	294	6.13	2.594
26-30	82	5.39	1.620	93	6.78	1.410	104	6.91	1.521	36	6.58	0.505
31-35	9	7.16	0.202	13	6.91	0.280	8	7.39	0.172	2	6.70	0.037
36-40	4	5.43	0.097	1	-	-	0	-	-	0	-	-
Total	476	6.62±0.71	5.164	454	6.61±0.53	4.239	836	6.11 ±1.00	6.451	1338	5.49±1.04	6.576
Avg. Girth		22.15 ± 4.61			21.89 ± 5.13			20.68 ± 4.84			17.34 ± 4.96	
Vol./ha (m^3)		27.123			23.342			19.221			12.287	
M.A.I.		6.780			5.835			4.822			3.071	

Fig. 2



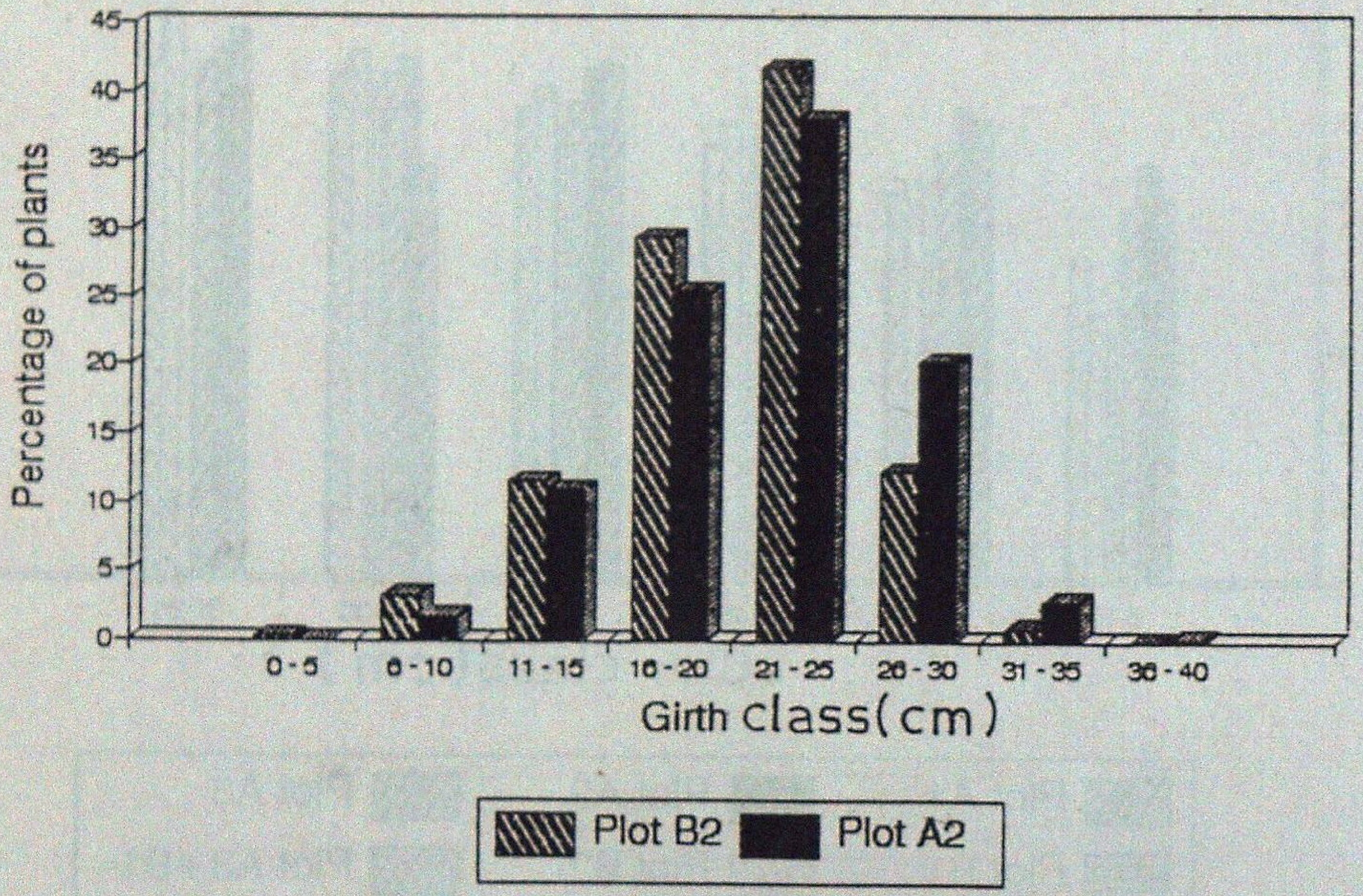
Comparative growth (girth GBH OB) in the plots receiving varied treatments

Fig. 3



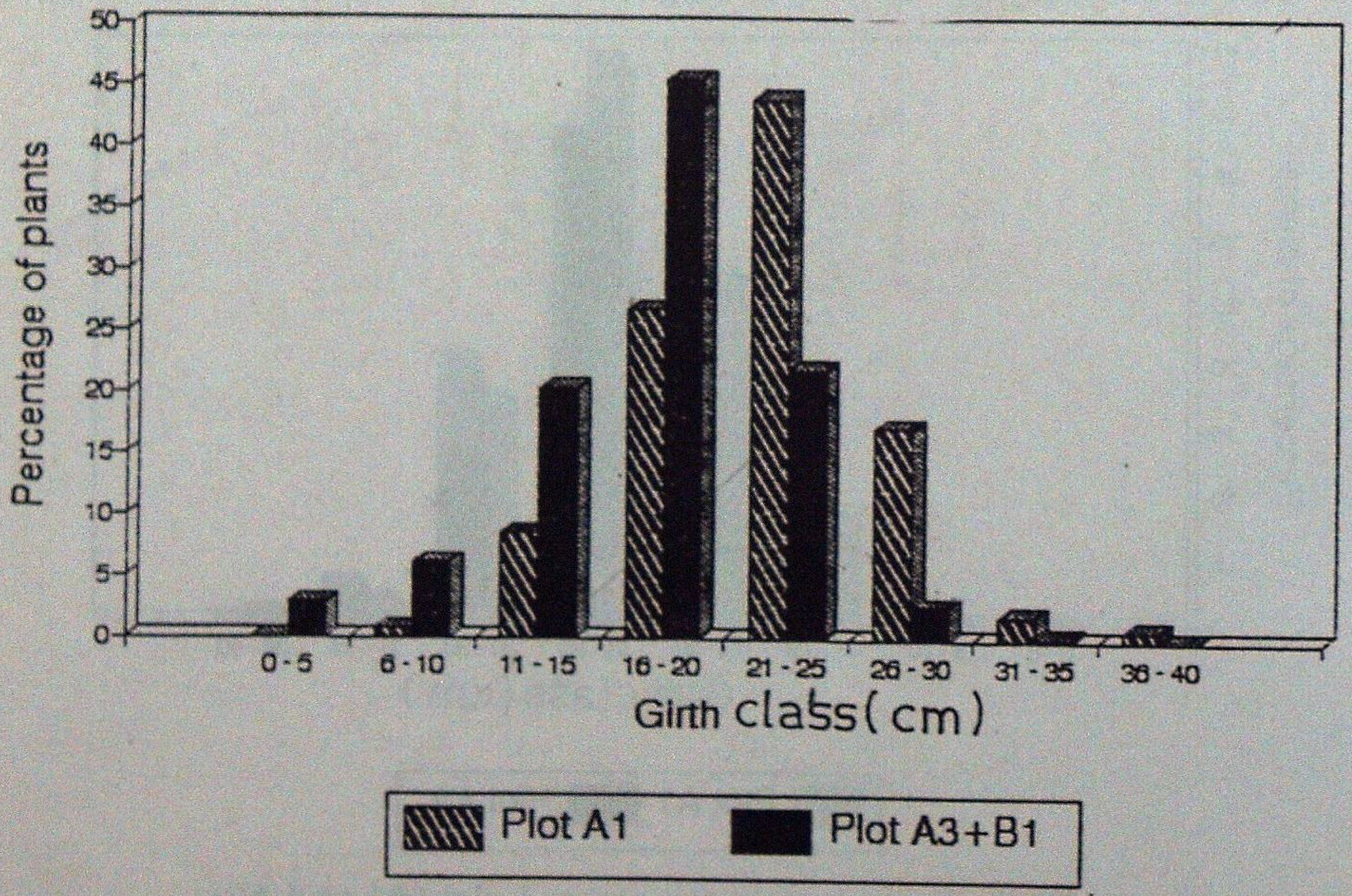
Plant percentage in the treated plot (A1 and A2)

Fig. 4



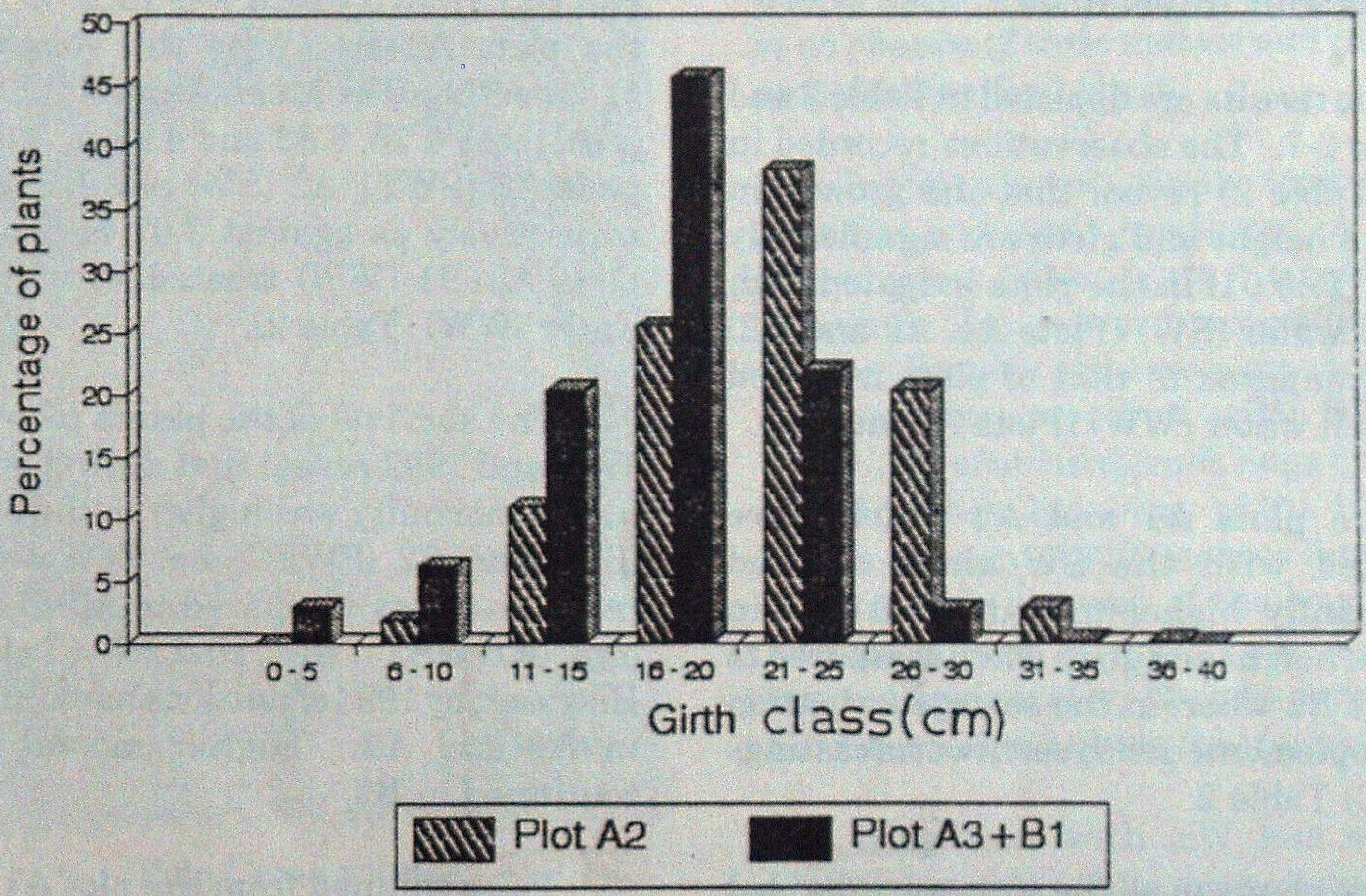
Plant percentage in various girth classes (A2 and B2)

Fig. 5



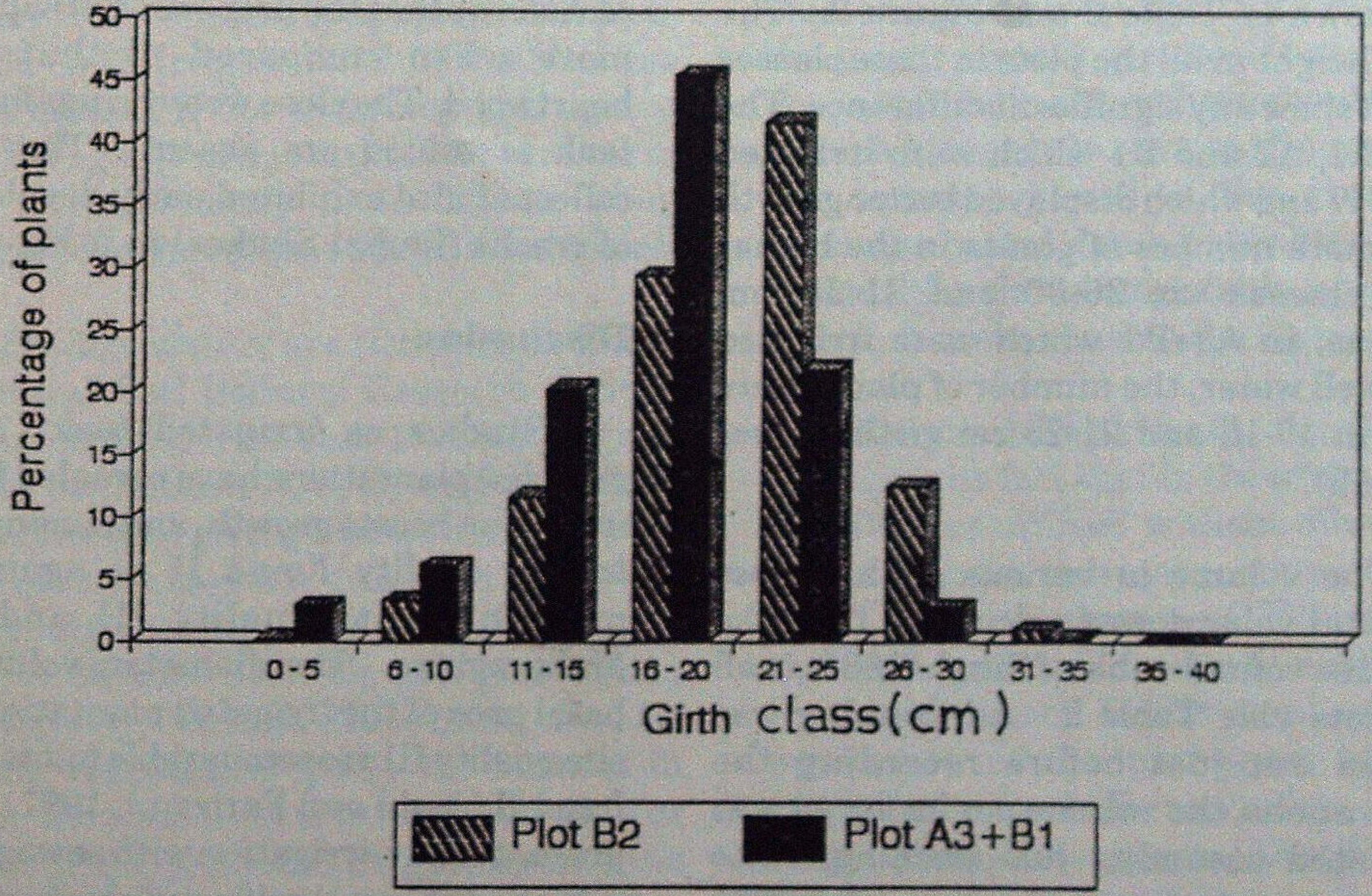
Plant percentage in various girth classes (A3 and B3)

Fig. 6



Plant percentage in various girth classes (A2, A3 and B1)

Fig. 7



Plant percentage in various girth classes (B2, A3 and B1)

Results and Inferences

The results are depicted in Table 2 and Figures 2-7. The observations recorded in 1991 (Table 2) reveal that the growth in terms of height and girth are significantly higher ($P<0.01$) in the plots irrigated with sewage water (SW) (Plots A1, A2 and B2) when compared to that of plots irrigated with well water (WW) (Plots A3 and B1).

The plots A1 and A2 which were irrigated with the SW alone showed significantly higher growth ($P<0.001$) in terms of height and girth when compared to the plot B2 wherein the sewage irrigation was supplemented with earthworm castings (SWEC) Table 2.

The plants in all the plots were divided into 5 cm girth classes. The number of plants in each girth class and the mean height in all the plots were calculated and are shown in Table 2 and Figure 2. The mean height in all the plots in these classes did not show any significant difference. The plots A1, A2 and B1 which were irrigated with SW and which displayed better growth have more number of plants in the higher girth classes viz 26-30 and 31-35 cm, whereas, in A3+B1 which were irrigated with well water, the number of plants were more in 10-15 and 21-25 cm girth classes (Table 2).

The volume in various girth classes and total volume was calculated from the total tree volume table of Singh (1981) in all the plots vide Table 2. As thinning was carried out just before recording the observations, the volume per ha for A1 was calculated assuming full stocking. The volume per hectare in the plots A1 (SWT) and A2 (SW) was 27.12 and 23.34 m^3 per ha, respectively. It was then followed by the plot B2 (SWEC) which was 19.29 m^3/ha. In the plots A3+B1 (WW) the volume was 12.28 m^3/ha. The Mean Annual Increment (MAI) was 6.78, 5.83 and 4.82 m^3/ha in the plots A1 (SWT), A2 (SW) and B2 (SWEC) respectively as against 3.07 m^3/ha in the plots A3+B1 (WW) treated with the well water (WW) (Table 2).

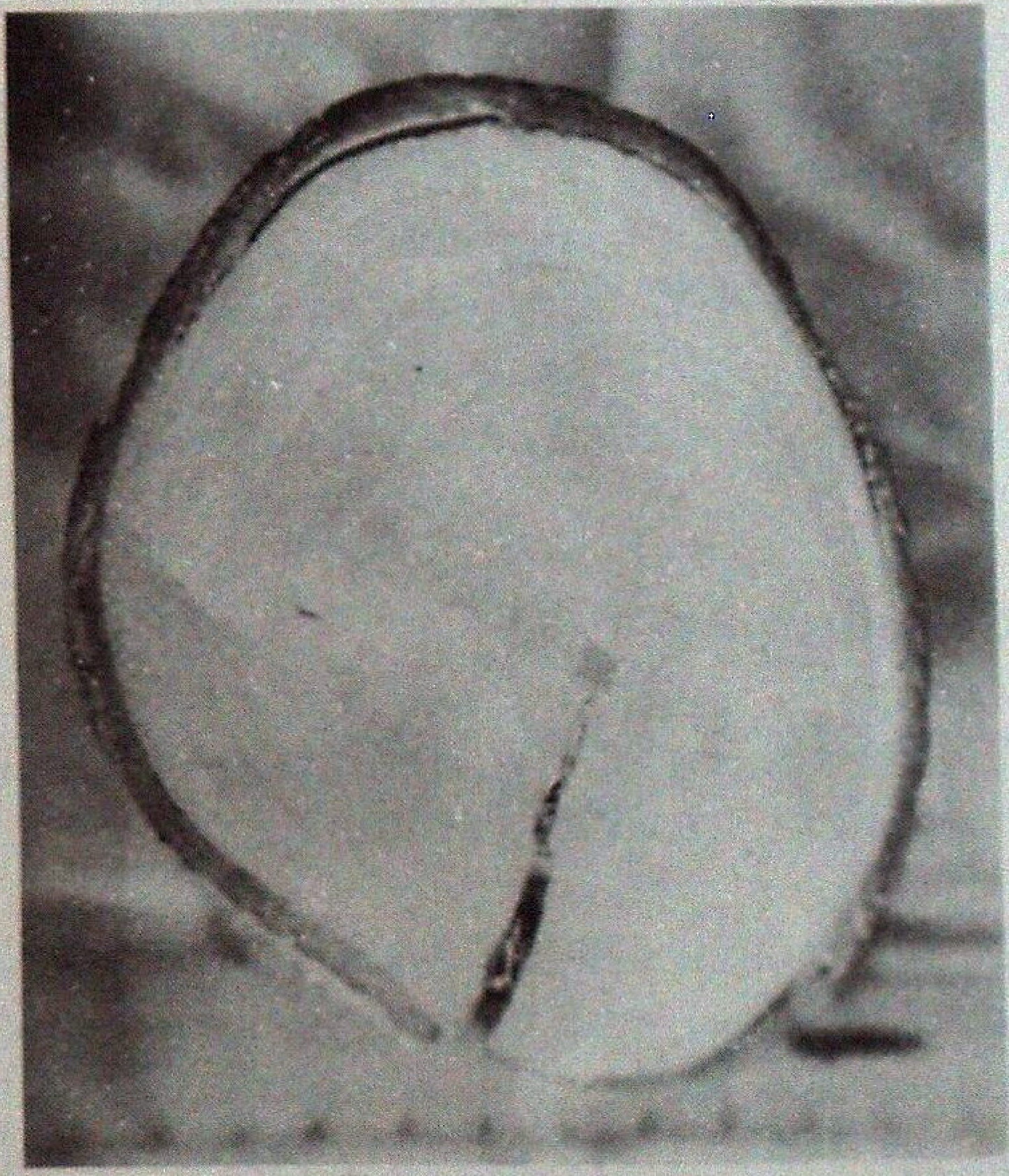
The survival of the plants recorded in 1991 and 1992 reveal that during one year period mortality was higher in the plots A2 (SW) and B2 (SWEC) i.e. 36% and 18% respectively as compared to A3+B1 (WW) and A1(WST) i.e. 10-12% (Table 1). However, by 1994 conditions have improved in A1 and A2. Higher mortality has continued in B2.

Poles thinned from the plot A1 (SWT) during 1991 when put to sale were not preferred by the purchasers. A cross section taken from the samples collected from this plot shows that the proportion of sapwood is more when compared to that of the heartwood. The close weavy rings for which teak is valued are absent. The sample collected also exhibited early development of cracks (Radial Shakes) in it Fig. 8.

Discussion

Studies on irrigated teak (*Tectona grandis*) plantations have revealed that the irrigation boosts growth, and is comparable to site quality I and II as against the prevailing site quality III and IV of Maharashtra. The diameter, volume and basal area of the irrigated plantation in the site quality III are comparable to site quality I and II (Joshi and Farooqui, 1991). In the present study, irrigation with sewage water (SW) had shown significantly higher growth ($P<0.01$) when compared to that of the plants irrigated with well water (WW) (Table 2).

Fig. 8



Pole Cross section

The volume per hectare in the plots irrigated with SW i.e. A1 (SWT), A2 (SW) and B2 (SWEC) was found to be 27.12, 23.34 and 19.29 m³/ha respectively as against the plots A3+B1 (WW) irrigated with WW which was 12.28 m³/ha. If the teak crop is irrigated with SW, gains are substantial over that of WW and ultimately much higher when compared to that of the rainfed plantations.

Sewage waters are rich in N, P, K and S Central Soil Salinity Research Centre, Karnal had reported that 181, 29, 270 and 150 kg per hectare N, P, K and S are added respectively by giving 5 irrigations of 7.5 cm each of untreated SW (Anon., 1990). The micronutrients Zn, Cu, Fe and Mn @ 1.28, 0.75, 4.68 and 1.37 kg are also added respectively. Though SW is being used for raising vegetable crops by the farmers in India, the possibility of toxic metals such as Cd, Cr, Fe, Cu, Zn and Pb getting into the food chain of animals and human beings cannot be ruled out (Misra and Srivastava, 1990). However, forestry crops wherein the usable parts are wood, timber or pulp, there is no chance of toxic metals and pathogens entering the food chain.

In the present study, teak (*Tectona grandis*) and study conducted by CSSRC, *Eucalyptus (Eucalyptus tereticronis)*, Subabul (*Leucaena leucocephala*) and Poplar (*Populus* spp.) have shown excellent growth when treated with SW. The possibility of utilising such huge quantity of 12500 million litres/day of the SW in our country (Anon., 1990) for tree farming will ensures safe disposal of the waste waters and utilisation of a N, P, K and micronutrient rich water, thereby reducing the fertilizer cost on raising the tree plantations.

Irrigation with SW has enhanced growth but in the short span of one year, the mortality was higher in the plots A2 (SW) and B2 (SWEC), being 36% and 18% respectively. In the present study, the plants are being treated with SW throughout the year. As teak is a deciduous plant, it does not remain active throughout the year, as such it cannot bio-drain effluents during the dormant period of the plant. The excessive water (and nutrients) perhaps making the plants vulnerable for pathogen attack, thereby causing the high mortality.

The other reason for the mortality may be due to the fact that in the present study, the SW was utilised without diluting it to adjust with the nutrient requirement of the plant. The treatment of SW was given through the year which might have increased the soil fertility and resulted in production of the pathogens which are responsible for high mortality. NEERI, Nagpur had also suggested that SW should be diluted to adjust with the requirement of the crop (Anon., 1985). However, the nutrient requirement of teak at various stages of the growth are not known. A detailed study of the water and nutrient requirement of teak during various stages of its growth, is therefore essential to arrive at definite conclusions.

The cross section of the stem collected from the material thinned in 1991 from the plot A1 (SWT) reveal that the proportion of sapwood is more when compared to that of heartwood. The wavy rings, which are characteristics of teak are also absent. Further, the sample collected had shown early splitting and development of the cracks (Radial-Shakes) Fig. 8). Though, the gain is substantial as evident by 5-6 m^3/ha/ann of the M.A.I. of the stem wood alone, together with branchwood it becomes quite attractive, but it appears that both strength and grain pattern for which teak is valued, are lacking. As such when desirable strength and grain pattern are absent, it will not fetch the price expected from (rain fed) teak. However, even if it is sold as firewood, it will give approximately 5-6 tonnes of firewood. Therefore, it appears that even if the timber quality is deteriorated and if it fetches the price of firewood, venture of irrigated teak can be viable.

Besides, the crop is bio-draining the SW which are otherwise hazardous. In agricultural crops, there is the possibility of toxic metals getting into the food-chain (Misra and Srivastava, 1990), but in the forestry crops wherein the end product is wood (non edible) such possibility is ruled-out. Thus, raising the forestry crops in SW not only gives substantial amount of revenue, but it is also eco-friendly as it bio-drains the SW and reduces the pollution hazards. By taking safety factors into consideration such cultivation can be best option.

Conclusions

1. Treatment of SW definitely enhances the height, girth and volume.

2. Returns of 5-6 m^3 of the stemwood ah ann˙, together with branch wood, are quite attractive and even if timber quality detoriates and fetches lower price, it would give more returns than that from agricultural crops.

3. SW should be utilised by diluting it to adjust with the requirement of the crop. It should not be supplied during the dormant period of the plant to avoid mortality.

4. The plants bio-drain the SW thereby decreasing the pollution hazards. Unlike vegetables, the usable parts being wood (non-edible), there are no health hazards.

5. Therefore, it is Eco-friendly and economically viable to utilise SW for irrigating forestry crop.

Acknowledgements

Thanks are due to Shri H.M. Gharte, Range Forest Officer, Dhule and Shri Dwarkadas Agarwal, the progressive farmer from Dhule, for their help extended towards field visit and collections of data. Thanks are also due to Shri H.M. Tikhe, Steno Typist for typing the manuscript.

SUMMARY

Discharge of Sewage Water (SW) is primary source of pollution especially near big cities. But their irrigational and manural potential can be harnessed for production of arboreal biomass. In Maharashtra and adjoining states a large number of farmers are going for irrigated teak (*Tectona*

***grandis*) plantations. Use of SW in this context will not only decrease cost of plantation by saving expenditure on manuring, but will reduce the pollution as well. In a case study of teak plan actions irrigated with SW, it was observed that growth in terms of height and girth were significantly higher ($P<0.01$) than the growth from plots irrigated with well water. However, mortality was higher in the plots irrigated with SW. Prospects of using SW as a potential for irrigation are discussed.**

वृक्ष वृद्धि के लिए गन्दी नालियों के जल की संभावनाएँ - सागौन (*टैक्टोना ग्रांडिस*) का एक अध्ययन

एम०जी० गोगटे, यु०एम० फारूकी व वी०एस० जोशी

सारांश

गन्दी नालियों का पानी छोड़ना, विशेषतः बड़े नगरों के पास, प्रदूषण का एक मुख्य कारण है । परन्तु उसकी सिंचाई और खाद संभावनाओं का उपयोग वृक्षों के जैवपुंज उत्पादन के लिए काम लाया जा सकता है । महाराष्ट्र और उसके साथ लगते राज्यों में बहुत सारे किसान सिंचाई करके सागौन (*टैक्टोना ग्रांडिस*) रोपवन उगाने में लगे हैं । इस संदर्भ में गन्दी नालियों का जल उपयोग करने से रोपवन लगाने का खर्च घट जाएगा क्योंकि खाद डालने का खर्च बचेगा, इससे प्रदूषण भी कम हो जाएगा । सागौन के रोपवन की सिंचाई इस गन्दे पानी से करने के एक अध्ययन में देखा गया कि कुएँ के पानी से सींचे भखूण्डों में हुई वृद्धि की तुलना में इससे हुई ऊँचाई और परिधि की वृद्धि सार्थकतः अधिक थी (पी <0.01) । किन्तु नालियों के पानी से सींचे गए भूखण्डों में पादप मरण अधिक हुआ । सिंचाई करने के लिए नालियों के पानी के उपयोग की संभावनाओं का विवेचन किया गया है ।

References

Anon. (1985). Waste Water Treatment. *Annual Report*, NEERI, Nagpur.

Anon. (1990). *Sewage Water : Utilisation Through Forestry Brochure*, Published by Central Soil Salinity Res. Institute, ICAR, Karnal (Haryana) pp 1-15.

Cromer, R.N. (1980) Irrigation of radiata pine with waste water : A review of the Potential for tree growth and water Renovation. *Aust. Forestry* **43** **(2)** : 87-100.

Edgar, J.G. and H.T.L. Stewart (1978). Waste Water disposal and reclamation using *Eucalyptus* and other trees. *Inst. Assoc. on Water Pollution Research Paper* **12,** 11p. Melbourne, Australia.

Joshi, V.S. and U.M. Farooqui (1991). Irrigated teak plantations in Maharashtra - A case study, *International Teak Symposium,* Thiruvananthapuram, Kerala. 1991.

Khisty, K.N. (1964). *Working Plan for the West Dhule Forest Division,* Nasik Circle, Maharashtra State, 1965-66 to 1984-85.

Misra, S.G. and C.P. Srivastava (1990). Management of Sewage Water. *Environmental Planning and Management in India.* Vol. II, Ed. R.K. Sapru, Ashish Publishing House, New Delhi.

Singh, S.P. (1981). Total Tree Volume Table for *Tectona grandis* (Teak) *Indian Forester,* **107** (10) : 621.

SELECTION DIFFERENTIAL AND PREDICTED GENETIC GAIN IN *TECTONA GRANDIS*

S.K. BAGCHI

Division of Genetics and Tree Propagation,
Forest Research Institute, Dehra Dun (India)

Introduction

Individual selection on the basis phenotypic superiority forms the basis of any tree improvement programme. The success of any individual tree selection largely depends on the magnitude of genetic variation. Where the magnitude of variation is high, the realised gain estimated from the difference between the progeny of the selected tree and the random sample of any base population will be high. In teak, the base population is highly variable and the estimations are made between the selected tree and the mean of five codominant trees. The higher selection differential thus obtained are indicative of higher gain. The choice of characters are need based and may depend upon their genetic control (heritability), their variability and also on the economic value. Here the stem quality was taken into consideration, which consists of plant height, clear bole length (cbl) and diameter at breast height (dbh). These characters are highly variable and reported to have sufficient genetic control (White, 1991). The search for superior trees was confined to the class-I sites, with uniform site conditions having stable and minimum microclimatic variations and expected to have greater phenotypic-genotypic ratios. The age group in this study was 25-109 years.

Materials and Methods

Plus trees and comparison trees of teak were selected from the southern zone of India. The comparison tree method was used for selection. The trees were measured quantitatively, e.g. height in meters, clear bole length in meters and dbh in centimeters. The investigation consists of 80 batches of trees (Table 1). Six tree data composed a batch. Out of the six trees, one was the plus tree and the rest comparison trees. Batches were considered to be the superior representatives of that particular plantation/location, and the locations were randomly spaced in a geographical locality covering three States of Karnataka, Tamil Nadu and Kerala.

The trees were more than 25 years of age and out of several characters three important traits, characteristic for growth and greater volume of wood production were measured. Those were total height (ht), clear bole length (cbl) and diameter at breast height (dbh). Batch numbers of Table 3 corresponds with that of the Table 1.

Statistical analysis : The Table 2 gives the one way analysis of variance showing significance of mean-squares of individual traits. Table 3 includes batch numbers, plus tree data, mean of comparison tree data,

Table 1

List of locations (batches) for selected trees.

Sl. No.	State	Forest Division	Range	Year of Planting	Age
1	2	3	4	5	6
1.	Tamil Nadu	Coimbatore South	Tunacadavu	1931	40
2.	Tamil Nadu	Coimbatore South	Tunacadavu	1931	40
3.	Tamil Nadu	Coimbatore South	Tunacadavu	1916	54
4.	Tamil Nadu	Coimbatore South	Tunacadavu	1930	41
5.	Tamil Nadu	Coimbatore South	Tunacadavu	1932	40
6.	Tamil Nadu	Coimbatore South	Tunacadavu	1932	40
7.	Tamil Nadu	Coimbatore South	Tunacadavu	1931	40
8.	Tamil Nadu	Coimbatore South	Tunacadavu	1934	38
9.	Tamil Nadu	Coimbatore South	Tunacadavu	1934	38
10.	Tamil Nadu	Coimbatore South	Tunacadavu	1931	41
11.	Tamil Nadu	Coimbatore South	Tunacadavu	1930	42
12.	Tamil Nadu	Coimbatore South	Tunacadavu	1934	38
13.	Tamil Nadu	Coimbatore South	Tunacadavu	1934	38
14.	Tamil Nadu	Coimbatore South	Tunacadavu	1934	38
15.	Tamil Nadu	Coimbatore South	Tunacadavu	1931	41
16.	Tamil Nadu	Coimbatore South	Tunacadavu	1931	41
17.	Tamil Nadu	Coimbatore South	Tunacadavu	1931	41
18.	Tamil Nadu	Coimbatore South	Tunacadavu	1931	41
19.	Tamil Nadu	Coimbatore South	Tunacadavu	1930	42
20.	Tamil Nadu	Coimbatore South	Tunacadavu	1930	42
21.	Tamil Nadu	Mudumalai	Kargudi	1925	56
22.	Tamil Nadu	Mudumalai	Kargudi	1925	56
23.	Tamil Nadu	Mudumalai	Kargudi	1925	56
24.	Tamil Nadu	Mudumalai	Kargudi	1925	56
25.	Kerala	Nemmara	Tunacadavu	1944	36
26.	Kerala	Nemmara	Tunacadavu	1925	55
27.	Kerala	Nemmara	Tunacadavu	1944	36
28.	Kerala	Nemmara	Tunacadavu	1925	55
29.	Kerala	Nemmara	Tunacadavu	1944	36
30.	Kerala	Nemmara	Tunacadavu	1944	36
31.	Kerala	Nilambur	Nilambur	1925	54
32.	Kerala	Nilambur	Nilambur	1928	51
33.	Kerala	Nilambur	Nilambur	1911	68
34.	Kerala	Nilambur	Nilambur	1930	41
35.	Kerala	Nilambur	Nilambur	1943	36
36.	Kerala	Nilambur	Nilambur	1919	60

(Contd...)

1	2	3	4	5	6
37.	Kerala	Nilambur	Nilambur	1943	36
38.	Kerala	Nilambur	Nilambur	1943	36
39.	Kerala	Nilambur	Nilambur	1930	49
40.	Kerala	Nilambur	Nilambur	1930	49
41.	Kerala	Nilambur	Nilambur	1932	47
42.	Kerala	Nilambur	Nilambur	1930	49
43.	Kerala	Nilambur	Nilambur	1928	51
44.	Kerala	Nilambur	Karulai	1931	48
45.	Kerala	Nilambur	Karulai	1920	59
46.	Kerala	North Wynad	Begur	1930	49
47.	Kerala	North Wynad	Begur	1895	85
48.	Kerala	North Wynad	Begur	1917	63
49.	Kerala	North Wynad	Begur	1923	57
50.	Kerala	North Wynad	Begur	1923	57
51.	Karnataka	Haliyal	Dandeli	1871	109
52.	Karnataka	Haliyal	Dandeli	1871	109
53.	Karnataka	Haliyal	Dandeli	1871	109
54.	Karnataka	Haliyal	Dandeli	1871	109
55.	Karnataka	Haliyal	Virnoli	1928	52
56.	Karnataka	Haliyal	Virnoli	1928	52
57.	Karnataka	Haliyal	Virnoli	1928	52
58.	Karnataka	Haliyal	Virnoli	1928	52
59.	Karnataka	Haliyal	Virnoli	1952	28
60.	Karnataka	Haliyal	Virnoli	1952	28
61.	Karnataka	Haliyal	Virnoli	1952	28
62.	Karnataka	Haliyal	Virnoli	1952	28
63.	Karnataka	Haliyal	Kulgi	1928	52
64.	Karnataka	Haliyal	Kulgi	1929	51
65.	Karnataka	Haliyal	Kulgi	1929	51
66.	Karnataka	Shimoga	Arasalu	1926	54
67.	Karnataka	Shimoga	Arasalu	1926	54
68.	Karnataka	Shimoga	Sacrebyle	1936	44
69.	Karnataka	Shimoga	Sacrebyle	1936	44
70.	Karnataka	Chikmagalur	Balehonnur	1935	45
71.	Karnataka	Chikmagalur	Balehonnur	1937	43
72.	Karnataka	Chikmagalur	Balehonnur	1939	41
73.	Karnataka	Chikmagalur	Balehonnur	1939	41
74.	Karanataka	Bhadravati	Lakolli	1926	54
75.	Karnataka	Mysore	Kakankote	1927	53
76.	Karnataka	Mysore	Kakankote	1928	52
77.	Karnataka	Mysore	Kakankote	1942	38
78.	Karnataka	Mysore	Kakankote	1941	39
79.	Karnataka	Mysore	Kakankote	1942	38
80.	Karnataka	Mysore	Kakankote	1942	38

selection differential, phenotypic standard deviation and predicted genetic gain values.

Table 2

Mean-squares of three characters

Source of variation	df	Plant height	Bole height	DBH
Bn batches	79	4.853***	3.129**	4.581***
wn batches	400	0.239	0.579	0.293

, * significant at 1% and 0.1% levels respectively

Selection differentials were calculated by the formula Xi-$\overline{X}$o, where Xi is the plus tree value and $\overline{X}$o is the mean of five comparison trees. The overall selection differential (at the end of the Table 3) was estimated by the same formula, Xi-$\overline{X}$o; where Xi represents the mean of plus trees and $\overline{X}$o the pooled mean of the comparison trees.

Phenotypic standard deviations were estimated as the standard deviations of six trees per batch and the pooled estimation, gave the overall standard deviation.

Heritability was estimated by the usual formula of $h^2 = \sigma^2g/\sigma^2p$,

where $\sigma^2p = \sigma^2g + \sigma^2e$.

Predicted genetic gain was estimated using the following formula (Singh and Chowdhary, 1979),

$R = i.h^2.\sigma p$, where,

i - is the standardised selection differential (some use the term 'k' instead of 'i' for the standardised selection differential).

h^2 - is the heritability, i.e. σ^2g/σ^2p

σ^2p being the phenotypic variance.

σp - is the phenotypic standard deviation.

The standardised selection differential values were obtained from Singh and Chowdhary (1979) as follows. In a single batch there were six trees and one out of six trees works out to be 16.66% or approximately 20% selection intensity. The standardised selection differential at 20% selection intensity was found to be 1.40.

The negative selection differentials in certain batches were due to the presence of water-holes or some such defects, when a codominant tree was selected for better growth and form.

It may be mentioned here that though the plus trees were originally selected on the basis of 1:500 to 1:1000, with a selection intensity of 0.2 to 0.1%, but the proportionate standardised selection differential was not used as the actual comparison is made with the five comparison tree values which formed the base population. Restricting the value of actual base population to the value of comparison trees not only allows us to select really superior phenotypes but also protects us from any overestimation of heritability. In fact, the population variability is so high that if we had used the value of actual base population, the predicted gain values would have been unrealistic. The values of comparison trees are superior than the base population and is therefore expected that a rigorous screening would give a sound footing to the estimated predicted gain for fulfilling the underlying promise.

Results and Discussion

The data on stem quality characters of

Table 3

Selection differential and predicted gain values.

Batch No.	Selected trees			Comparison tree mean			Selection differentia			Phenotypic Std. deviation			Predicted genetic gain		
	Ht	Cbl	Dbh	Ht	Cbl	Dbh	Ht	Cbl	Dbh	Ht	Cbl	Dbh	Ht	Cbl	Dbh
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	30.0	22.0	58.0	24.8	14.4	52.12	5.2	7.6	5.88	2.6246	3.8816	2.5605	3.4936	4.4289	3.3553
2	28.0	20.0	51.2	27.0	13.2	44.92	1.0	6.8	6.28	1.1690	4.1312	3.5781	1.5561	4.7137	4.6887
3	31.0	20.0	32.0	25.4	15.2	55.92	5.6	4.8	3.52	3.2659	3.0332	12.9373	4.3472	3.4609	16.9530
4	32.0	20.0	47.5	25.8	14.2	45.50	6.2	5.8	2.00	2.9269	3.0605	1.4052	3.8959	3.4920	1.8414
5	27.0	18.0	42.0	24.9	11.3	54.56	0.9	6.7	-12.56	1.2145	3.1530	7.2207	1.6166	3.5975	9.4620
6	29.0	18.0	47.2	24.8	12.8	47.58	4.2	5.2	-0.36	2.3452	3.2042	4.9278	3.1217	3.6559	6.4574
7	27.5	19.0	42.4	27.1	9.1	49.08	0.4	7.9	-6.68	0.8756	4.4017	5.8779	1.1655	5.0223	7.7024
8	27.5	16.0	40.2	26.2	9.3	43.28	1.3	6.7	-3.08	0.6646	3.0400	2.8994	0.8846	3.4686	3.7994
9	27.0	16.0	48.6	28.0	9.4	49.56	-1.0	6.6	-0.96	0.7528	3.4496	3.1699	1.0021	3.9355	4.1539
10	29.0	20.0	41.2	24.2	11.8	35.64	4.6	8.2	5.56	2.3664	3.8166	3.5223	3.1499	4.3547	4.6156
11	31.0	15.0	42.2	28.2	13.4	41.92	2.8	2.1	0.28	2.2509	2.8592	5.1059	2.9962	3.2623	5.6908
12	26.0	18.0	43.2	25.9	10.1	47.08	-0.1	8.0	-3.88	1.4972	4.7793	3.1328	1.9929	5.4532	4.1052
13	29.5	18.0	40.0	28.6	13.0	45.92	0.9	5.0	-5.92	1.4053	2.6394	4.2552	1.8706	3.0116	5.5760
14	28.0	19.5	40.0	25.11	13.2	38.80	2.9	11.3	1.20	1.8552	3.9969	5.9168	2.4695	4.5605	7.7534
15	33.0	22.5	54.2	29.6	11.0	47.36	3.4	11.5	6.84	2.4833	4.9032	4.0924	3.3055	5.5946	5.3627
16	32.0	20.0	51.6	27.8	11.4	45.48	4.2	8.6	6.12	2.8107	4.1673	5.7156	3.7413	4.7549	7.4897
17	32.0	18.0	55.5	30.8	11.2	45.20	1.2	6.0	10.48	2.0976	3.0111	5.8987	2.7921	3.4357	7.7297
18	30.0	16.5	53.0	27.4	12.2	39.48	2.6	4.3	13.52	1.4719	2.2895	6.9012	1.9592	2.6123	9.0433
19	31.0	20.0	49.4	28.6	14.0	46.28	2.4	6.0	3.12	2.0976	2.9665	5.3126	2.7921	3.3048	6.9616
20	28.0	19.0	36.0	26.4	12.4	41.68	1.6	6.6	-5.68	1.6329	3.5071	5.7336	2.1736	4.0016	7.5133
21	18.8	7.5	44.7	18.5	6.7	38.96	0.3	0.8	5.74	0.9607	2.2286	3.7403	1.2788	2.5428	4.9013
22	25.5	12.5	45.2	19.1	5.1	40.92	6.4	7.4	4.28	4.1118	3.7372	3.7745	5.4732	4.2641	4.9461
23	22.0	11.0	43.3	19.2	8.4	33.90	2.8	2.6	9.40	1.3292	1.6329	6.3181	1.7693	1.8631	8.2792
24	26.0	13.0	48.1	21.8	9.4	38.00	4.2	3.6	10.10	2.1679	3.1464	6.1927	2.8857	3.5900	8.1149
25	28.5	15.5	46.8	21.2	9.6	40.36	7.3	5.9	6.44	3.8002	2.5183	2.8161	5.0584	2.8734	3.6902
26	26.5	15.0	57.3	21.0	8.7	49.60	5.5	6.3	7.70	2.5183	3.8955	5.1990	3.3521	4.4448	6.8128
27	24.5	13.0	48.7	22.6	10.5	45.26	1.5	2.5	3.44	1.8819	2.5380	4.9444	2.5050	2.8959	6.4791

(Contd...)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
28	27.5	13.5	58.6	21.5	9.5	54.12	5.7	4.0	4.48	2.5642	3.1252	7.1115	3.4132	3.8659	9.3193
29	30.0	17.0	42.7	22.6	11.2	39.80	7.4	5.8	2.90	4.2269	2.6882	6.4914	5.6264	3.0672	8.5063
30	26.3	15.5	44.4	23.2	12.1	41.02	3.1	3.4	3.38	2.1785	2.6957	3.5533	2.8998	3.0758	4.6562
31	35.0	20.0	64.4	26.5	12.2	56.38	8.5	7.8	8.02	8.0400	3.3912	11.2339	10.7020	2.2820	14.7209
32	34.0	22.0	50.8	32.1	15.3	53.60	1.9	6.8	-2.80	1.7600	2.9053	7.1006	2.6089	3.3152	9.3046
33	36.5	22.0	56.3	31.0	20.4	70.18	5.5	3.6	16.12	3.7204	3.0332	9.5897	4.9522	3.4609	12.5663
34	35.0	20.0	73.9	35.1	14.8	56.96	-0.1	5.2	16.94	1.6253	2.4221	8.9276	2.1634	2.7636	11.6987
35	27.5	15.0	49.5	28.3	9.6	40.92	-0.8	5.4	8.58	2.7325	3.8842	7.6967	3.6372	4.4319	10.0858
36	36.0	19.0	73.8	30.8	13.4	65.26	5.2	5.6	8.54	4.4572	3.5023	7.5414	5.9329	3.9961	9.8826
37	28.0	13.0	46.0	26.1	10.5	37.10	1.5	2.5	8.90	1.6568	1.2813	6.9617	2.2054	1.4619	9.1226
38	35.0	20.0	54.9	28.0	15.2	40.16	7.0	4.8	14.74	2.9439	3.0166	7.3592	3.9186	3.4419	9.6435
39	36.5	19.0	67.1	36.1	13.9	56.96	0.4	5.1	10.14	0.4083	2.5249	6.7043	0.5435	2.8809	8.7853
40	38.0	22.0	50.4	34.4	15.0	54.82	3.6	7.0	-4.42	3.5777	4.7924	8.4530	4.7623	5.4681	11.0768
41	32.0	18.0	43.3	35.4	14.7	51.86	-3.4	3.3	-8.56	1.7512	1.6658	6.7444	2.3310	1.9007	8.8379
42	35.5	22.0	47.4	33.0	14.2	45.16	2.5	7.8	2.24	1.3934	4.0373	5.4928	1.8548	4.6066	7.1978
43	30.5	18.5	55.4	31.9	13.6	46.24	-1.4	4.9	9.16	1.9916	3.7339	4.4392	2.6510	4.2604	5.8171
44	33.5	17.0	54.8	23.6	14.0	39.72	5.1	3.0	15.08	2.7157	3.1464	7.0780	3.6149	3.5900	9.2750
45	35.0	23.0	70.6	33.4	15.1	66.80	1.6	7.9	3.80	1.5055	4.3407	3.5007	2.0039	4.9527	4.5673
46	27.0	10.6	51.7	22.7	9.4	42.66	4.9	1.2	9.04	2.8729	3.1023	6.1896	3.8241	3.9399	8.1109
47	36.9	15.0	82.7	32.8	15.4	67.74	4.1	-0.4	14.96	2.0894	2.4771	9.6854	2.7012	2.8264	12.6917
48	27.0	14.4	52.3	22.9	8.8	58.86	4.1	5.6	-6.56	2.4441	2.6440	12.0740	3.2533	3.0168	15.8218
49	25.4	10.5	51.4	22.4	6.7	46.28	3.0	3.8	5.12	2.0363	2.7235	5.7451	2.7105	3.1075	7.5284
50	25.6	15.0	52.5	22.9	9.6	46.08	2.7	5.4	6.42	2.1554	2.6676	9.4949	2.8691	3.0437	12.4421
51	25.0	11.5	43.9	19.9	8.2	36.62	5.1	3.3	7.28	3.2673	2.5049	6.8225	4.3491	2.8581	8.9402
52	25.0	15.0	39.2	22.3	10.4	40.88	2.7	4.6	-1.68	1.7209	4.5240	11.2239	2.2907	5.1619	14.7078
53	20.0	12.5	30.2	17.8	7.3	34.96	2.2	5.2	-4.76	1.9149	2.6164	6.2089	2.5489	2.9853	8.1361
54	23.2	15.5	35.0	20.8	8.6	36.94	2.4	6.9	-1.94	1.2728	3.1741	5.7839	1.6942	3.6216	7.5792
55	24.5	10.5	43.6	21.5	8.6	32.54	3.0	1.9	11.06	2.1679	1.4634	8.4388	2.8857	2.8033	11.0582
56	28.0	14.0	35.7	22.6	9.1	33.44	5.4	4.9	2.26	3.1937	2.5577	5.9294	4.2511	2.9183	7.7699
57	31.0	14.0	41.0	26.8	12.0	38.00	4.2	2.0	3.00	3.0984	1.5381	5.3318	4.1243	1.7553	8.2972
58	27.0	13.0	40.1	24.1	11.3	32.58	2.9	1.7	7.52	2.4983	1.9093	5.4268	3.3255	2.1773	7.1113
59	21.5	13.8	30.2	18.1	9.6	27.54	3.4	4.2	2.66	1.8641	2.2518	2.1904	2.4813	2.5693	2.8703
60	23.0	17.0	33.4	18.6	10.2	30.02	4.4	6.8	3.38	1.8601	3.5099	5.1406	2.4759	4.0050	6.7362
61	22.5	13.5	35.0	20.1	11.2	29.80	2.4	2.3	5.20	1.6473	1.5540	3.8182	2.1927	1.7731	5.0034

(Contd...)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
62	20.8	12.5	31.8	17.7	11.7	27.50	3.1	0.5	4.34	2.2284	1.7111	2.7462	2.9662	1.3519	3.5986
63	24.0	13.0	32.5	18.3	8.7	24.26	5.7	4.3	8.24	3.0290	4.1954	3.9006	4.0319	4.7870	5.1113
64	21.0	14.0	31.8	19.4	9.1	29.94	1.6	4.9	1.86	2.3805	2.6157	1.3248	3.1687	2.9845	1.7360
65	25.0	8.5	36.6	20.8	7.0	29.42	4.2	1.5	7.18	2.4495	3.0455	7.7414	3.2605	3.4749	10.1443
66	26.5	14.8	46.2	19.6	7.0	37.12	6.9	7.8	9.08	3.0024	3.4409	6.9724	3.9965	3.9261	9.1366
67	25.8	12.3	54.1	21.7	7.7	48.62	4.1	4.6	5.48	2.2319	3.5375	9.7140	2.9709	4.0363	12.7292
68	19.6	11.8	33.4	16.3	8.4	29.22	3.3	3.4	4.18	3.6779	3.1653	9.8242	4.8956	3.6116	7.6320
69	19.5	12.3	39.8	20.2	9.9	29.56	-0.7	2.4	10.24	1.7694	2.9620	5.2496	2.3552	3.3796	6.8791
70	25.0	12.5	38.2	22.7	7.1	36.04	2.3	5.4	2.16	2.8358	2.8983	5.8784	3.7747	3.3070	7.7031
71	29.0	16.5	43.0	25.1	11.7	41.44	3.9	4.8	1.56	6.4323	4.0125	3.8647	8.5620	4.5783	5.0643
72	23.8	15.0	34.4	23.1	4.2	28.80	0.7	10.8	5.60	2.3097	4.5897	8.2102	3.0744	5.2368	10.7586
73	27.5	11.0	38.2	24.8	9.3	30.26	2.7	1.7	7.94	1.6956	1.1143	4.6910	2.2570	1.2714	6.1471
74	31.3	12.8	57.6	24.6	12.0	47.88	6.7	0.6	9.72	3.1758	2.1550	10.0102	4.2273	2.4589	13.1174
75	21.5	13.2	40.4	19.6	8.4	33.26	1.9	4.8	7.14	1.0968	2.3401	3.3261	1.4599	2.6701	4.3585
76	17.6	8.8	38.2	14.8	6.1	25.30	2.8	2.7	12.90	3.2396	1.8651	7.0975	4.3122	2.1281	9.3006
77	23.6	11.8	44.6	18.0	6.6	31.18	5.6	5.2	13.42	3.5399	2.8640	8.5326	4.7119	3.2678	11.1811
78	25.0	11.8	31.8	15.5	7.4	23.12	9.5	4.4	8.68	5.3635	2.9084	8.3217	7.1394	3.3185	10.9048
79	20.6	13.2	33.4	17.7	9.8	25.72	2.9	3.4	7.68	2.2196	1.5118	4.0728	2.9545	1.7250	5.3370
80	19.1	8.8	43.0	14.6	7.0	23.42	4.5	1.8	17.58	2.8247	2.1509	8.0579	3.7599	2.4542	10.5591
Mean	27.64	15.0	46.88	24.3	10.77	42.0	3.3	4.23	4.88	1.1999	0.8901	2.4204	1.5972	1.0156	3.1717

plus trees and comparison trees and the predicted gain values are given in Table 3. The selection differentials between plus trees and the mean of comparison trees of 80 batches are also given in the same table, owing to the separate nature of data in each plantation area. Plus trees from Nemmara, Kerala, 1944 plantation, and, plus trees from Arasalu, Shimoga, Karnataka, 1926 plantation show much promise. Their batch numbers as per Table 1, are 25, 31 and 66. In these three cases, the selection differentials for the three characters are more or less of similar magnitudes and quite a good amount of gain can also be predicted over the other superior types. The highest selection differential for individual tree here was observed to be 8.5 for height, 11.5 for cbl and 17.58 for dbh, for batch numbers 31, 15 and 80 respectively. The varying magnitudes of selection differentials among different characters clearly defines the variable genetic control inspite of reported correlations among the characters. Similarly, the maximum predicted gain for height was observed to be 10.7, 5.59 for cbl and 16.95 for dbh. In view of the above an effective selection may therefore improve the stem quality. This supposition is based on the results from the top 5% of the batches where the height ranges from 38.0 m to 36.0 m, for cbl 24.0 m to 22.0 m and for dbh it ranged from 86.3 cm to 73.8 cm. It is evident that values of the upper 5% lot for the three characters are far superior and the expected genetic value from the best 5% of the batches are likely to exceed the general mean.

It is essential to know the selection differential and genetic gain concepts before exercising selection in commercial tree species; and genetic gain is simply the product of selection differential and heritability. Therefore, the rate of tree improvement can be increased or decreased by influencing the selection differential or heritability, or by reducing the total variance. The gain thus achieved from plus trees can immediately be realised through mass scale clonal propagation by vegetative means for general plantation purposes and further gains can be achieved subsequently by progeny selections and selective breeding.

It may be concluded that, (1) the stem quality character variabilities were high; (2) heritabilities of individual traits were high; and with a selection intensity of 20%, the genetic gain as estimated, is expected to be realised on selection.

Acknowledgements

The author gratefully acknowledges the help rendered by Shri C.J.S.K. Emmanuel during the collection of data.

SUMMARY

In a study of 80 batches of teak trees, selection differential and predicted genetic gain values were estimated. This involved individual character variation analysis, estimation of heritability and computation of predicted gain values. Predicted gain values were estimated for individual batches along with an overall estimate. Some individual batch values (predicted gain) were found to be higher and the upper 5% values of overall batches were substantially high than the overall mean-estimate of the predicted gain values. This along with 20% selection intensity, significantly different mean-square values and high heritability assure shifting of the mean towards the direction of selection. The batches with higher predicted gain values were indicated for use in the mass clonal multiplication programme and also for further selective breeding and improvement.

चयन भेद और *टैक्टोना ग्रांडिस* के पूर्व कथित आनुवंशिकीय लाभ

एस०के० बाग्ची

सारांश

सागौन वृक्षों की 80 टोलियों के अध्ययन से चयन भेद और पूर्व कथित आनुवंशिक लाभ अर्हाओं का आकलन किया गया। अध्ययन में व्यष्टिगत चरित विभिन्नता का विश्लेषण, पित्रागति का अनुमान और पूर्व कथित लाभ अर्हाओं का संगणन करना पड़ा। समग्र आकलन के साथ-साथ प्रत्येक टोली की पूर्व कथित लाभ अर्हाओं का आकलन करना पड़ा। व्यष्टिगत टोलियों की कुछ (पूर्व कथित लाभ) अर्हाएं तो काफी अधिक पाई गई और समग्र टोलियों की 5% से ऊपर की अर्हाएँ तो पूर्व कथित लाभ अर्हाओं के समग्र माध्य अनुमान से काफी ज्यादा थी। यह 20% चयन चण्डता, काफी भिन्न माध्य वर्ग अर्हाओं और अधिक पित्रागति साथ लेने पर माध्य का चयन की दिशा में हटते जाना सुनिश्चित बना देता है। अधिक पूर्व कथित लाभ अर्हाओं वाली टोलियाँ विस्तृत कृन्तकीय बहुलन कार्यक्रम में व्यवहार करने तथा आगे के चयन प्रजनन और परिष्कार कार्यों में उपयोग के लिए सूचित की गई हैं।

References

Singh, R.K. and B.D. Chowdhary (1979). *Biometrical Methods in Quantitative Genetic Analysis*. Kalyani Publishers, New Delhi.

White, K.J. (1991). Teak: Some aspects of Research and Development. *RAPA Publication* 1991/17, FAO, Bangkok.

Snippets DATA BASE

A new database, a Forest of Choices : The guide to sustainable use of Forests, contains reference information including articles, papers, proceedings, books, news items, photographs, and video. The database holds 3,000 pages of information and 2 hours of video on current issues including forest management, wood certification, green business, non-timber forest products, tropical forests and sustainable design. Cost is $ 150 for CD or diskette versions. For more information contact Tree Talk, Inc. P.O. Box. 426, 431 Pine St., Burlington, VT 05402 (USA). Fax 8002-863-4344.

Source : *Forest Products Journal*, Vol. 45, No. 5

GROWTH RESPONSES TO IRRIGATION : EKSAL (AMBHADI) TEAK PLANTATION - A CASE STUDY

M.G. GOGATE*, U.M. FAROOQUI** AND V.S. JOSHI***

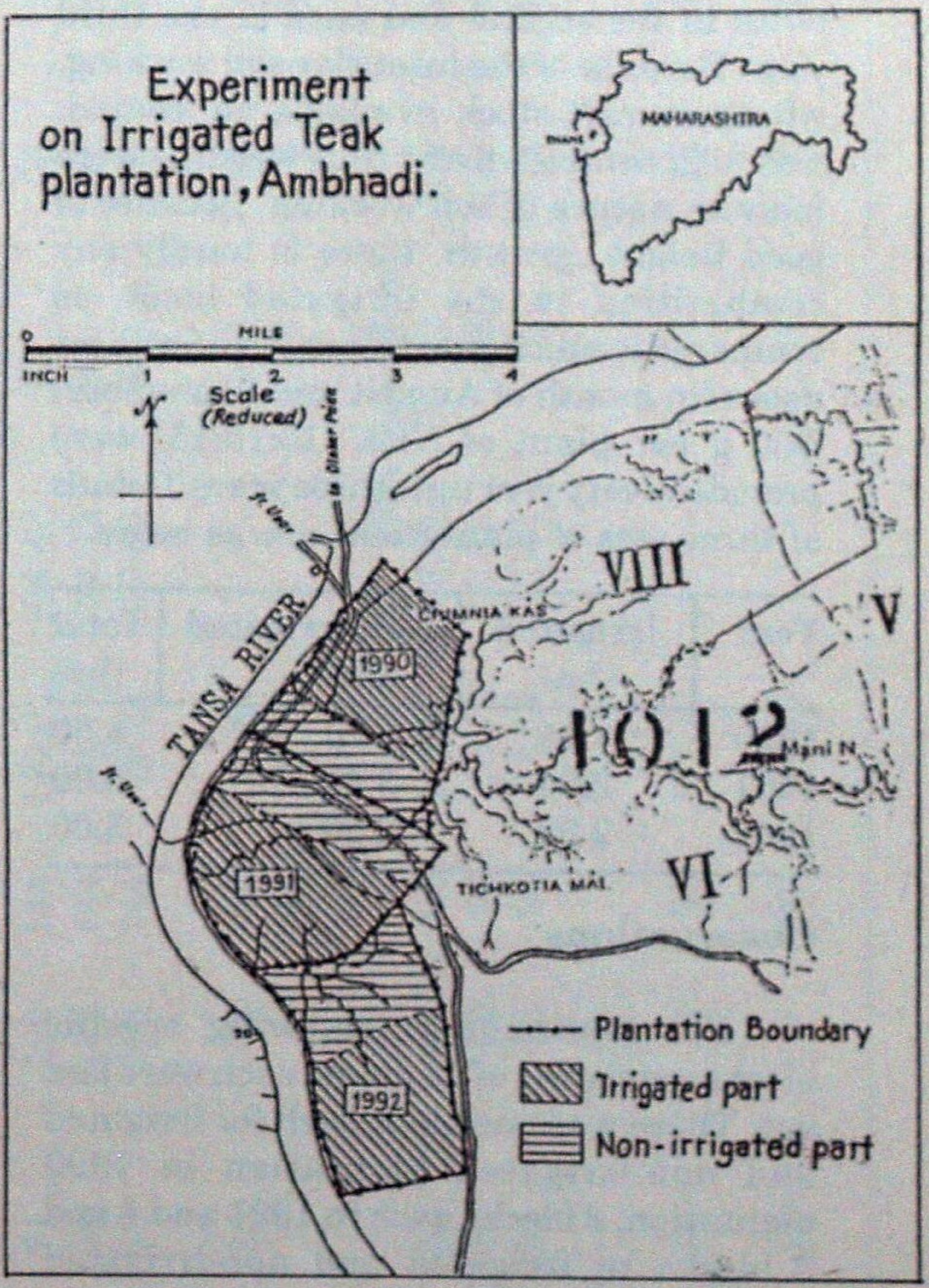
Introduction

A trend of commercial scale teak plantations with high inputs of irrigation, fertilizers etc. is on the rise, throughout the country. Projected returns from such plantations, however, has become a controversial issue. Teak being deciduous, have a period of dormancy and thus it is necessary to critically assess response to high inputs during different seasons to optimise returns and avoid possible ill effects of excessive irrigation.

Background

Forest Development Corporation of Maharashtra (FDCM) Limited has been raising teak plantations in a big way since 1974. Thane Forest Project Division of FDCM is located in the Northern Konkan coastal zone. This division initiated irrigated teak plantation programme in 1990 rains. The plantation site is located at Eksal (Ambhadi) Tal, Wada, District Thane (Fig. 1) which receives annual rainfall of 2500 mm, spread mainly from 3rd week of June to middle of October. Soil depth at the plantation site varies from shallow to deep and the 1991 plantation site has predominantly shallow soil.

Fig .1


Experiment on Irrigated Teak plantation, Ambhadi.
MAHARASHTRA
0
MILE
INCH
1
2
3
4
Scale (Reduced)
N
TANSA RIVER
CHIMNIA KAS
VIII
V
1012
Mani N.
TICHKOTIA MAL
VI
1990
1991
1992
Plantation Boundary
Irrigated part
Non-irrigated part

---

* Conservator of Forests, Forest Research Circle, Pune (Maharashtra)

** Asstt. Forest Utilization Officer, O/o The Principal Chief Conservator of Forests, Nagpur (Maharashtra)

*** Divisional Forest Officer (Research), Pune (Maharashtra)

Planting Technique

Area was ploughed and at a spacement of 2 m x 1.5 m, teak stumps were planted. The area is being channel irrigated at an interval of about 3 weeks from end of monsoon to onset of next monsoon. Amount of water released every time, has not been regularly monitored and therefore, it will suffice to say that normal flow irrigation method is adopted. Weedings in the plantations were as per normal practice i.e. plantations were tended thrice in the first, twice in the second and once in the third year. Because of the intensive soil working, whatever root stock available on around, was fully controlled and thus weeding were more in nature of soil working. Because of good height growth, there is hardly any competition in the irrigated block as compared to unirrigated block. Two fertilizer doses (in month of August and September) @50 g per plant of NPK (15:15:15) were provided every year upto three years. Details of three sets of plantations are as below :

Year	Irrigated (ha)	Non irrigated (ha)	Total (ha)
1990	3.75	0.75	4.50
1991	2.00	3.00	5.00
1992	2.50	2.50	5.00

Observations

For continuous monitoring specific blocks consisting of 48 plants each were laid out. There was one block each for irrigated and non-irrigated plantation in 1990 plantation, 3 blocks each in 1991 and 4 and 2 blocks in irrigated and non-irrigated plantations in 1992 plantations. Observations on survival and height for each plant in the block were made every month during November 1991 to August 1993 and then in August 1994 (Figs. 2 to 4). Survival and height measurements for the months May 1992, May 1993 and October 1994 for 1990, 1991 and 1992 plantations are compared to assess increments (Table 1).

As intensity of this block sampling was inadequate by 10% systematic random sampling, observations on survival, height and girth for each plant in the 1990, 1991 and 1992 plantations were recorded during March 1993 and October 1994 (Table 2).

Girth classwise distribution of plants in irrigated/non-irrigated plants, is depicted in Fig 5. In response to irrigation, a sizable number of plants are in higher girth classes in all three plantations. The growth data were analysed statistically using anova test.

Results

Table 1 and Figs. 2 to 4 reveal that the height increments in irrigated plants, over non-irrigated plants (in percentage) during the Ist to 4th years of plantations are as follows.

Height gain over the previous year in each plantation has been compared (May 1993 over May 1992 and October 94 over May 1993) and differences computed and compared in percentile over the earlier benchmarks are as below :

	1992	1991	1990
Ist year	4448%	-	-
IInd year	141%	113%*	-
IIIrd year	-	120%	1024%
IVth year	-	-	397%

*Poor response is related to shallow soil.

It will be seen that the difference in the

Table 1

Observations of Random Block Sampling.

Observ-ations	Non- irrigated					Irrigated					Percentage gain (%)
	Survi-val (%)	No.	Total	Mean (Ht.) (cm)	S.D.	Survi val (%)	No.	Total	Mean (Ht.) (cm)	S.D.	
					1990 plantation						
Oct. 94	60	29	48	63.86	30.26	85.4	41	48	440.00	109.00	
May, 93	77	37	48	34.62	13.65	89.6	43	48	323.81	115.24	
May, 92	98	47	48	20.15	11.99	93.7	45	48	175.58	80.00	
Difference											
4th year	16	8	48	29.24	-	4.2	2	48	116.19	-	397
3rd year	21	10	48	14.47	-	4.1	2	48	148.23	-	1024
					1991 plantation						
Oct. 94	71	102	144	182.01	108.47	68	98	144	216.24	124.62	
May,93	96	138	144	84.17	54.22	93	134	144	98.69	54.52	
May,92	95	138	144	26.21	19.30	94.4	136	144	33.42	17.92	
Difference											
3rd year	25	36	144	97.84	-	25.0	36	144	117.55	-	120
2nd year	1	-	144	57.96	-	1.4	2	144	65.27	-	113
					1992 plantation						
Oct.94	84	81	96	122.82	43.82	82	158	192	287.44	113.39	
May,93	96	92	96	15.72	7.18	88	169	192	136.38	66.87	
May,92	97	93	96	13.54	7.13	92	177	192	39.40	23.45	
Difference											
2nd yr											
May,93	11	11	96	107.10	-	5.7	11	192	151.06	-	141
1st yr											
May, 92	1	1	96	2.18	-	4	8	192	96.98	-	4448
May,93											

Fig. 2A

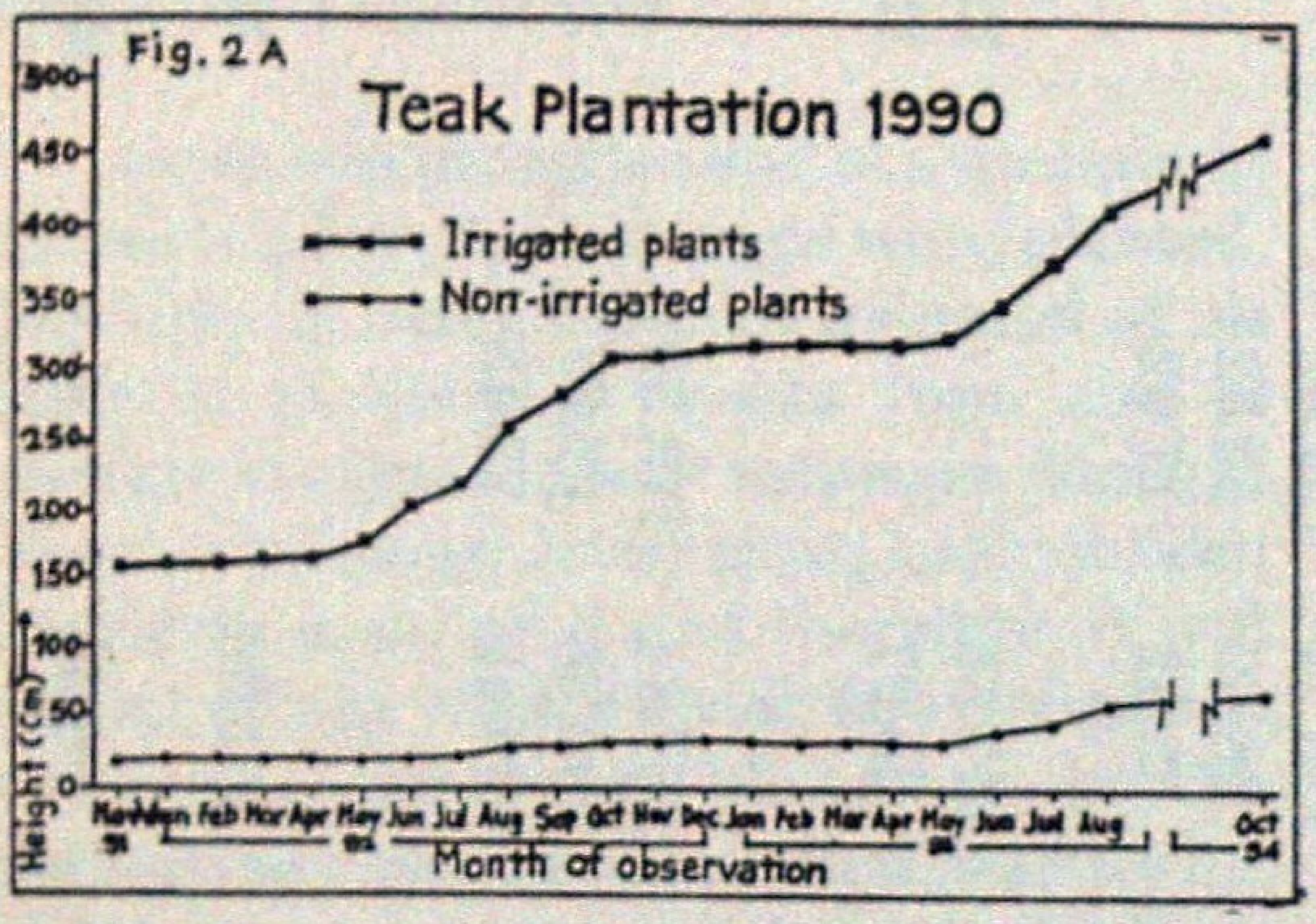


Fig. 2B

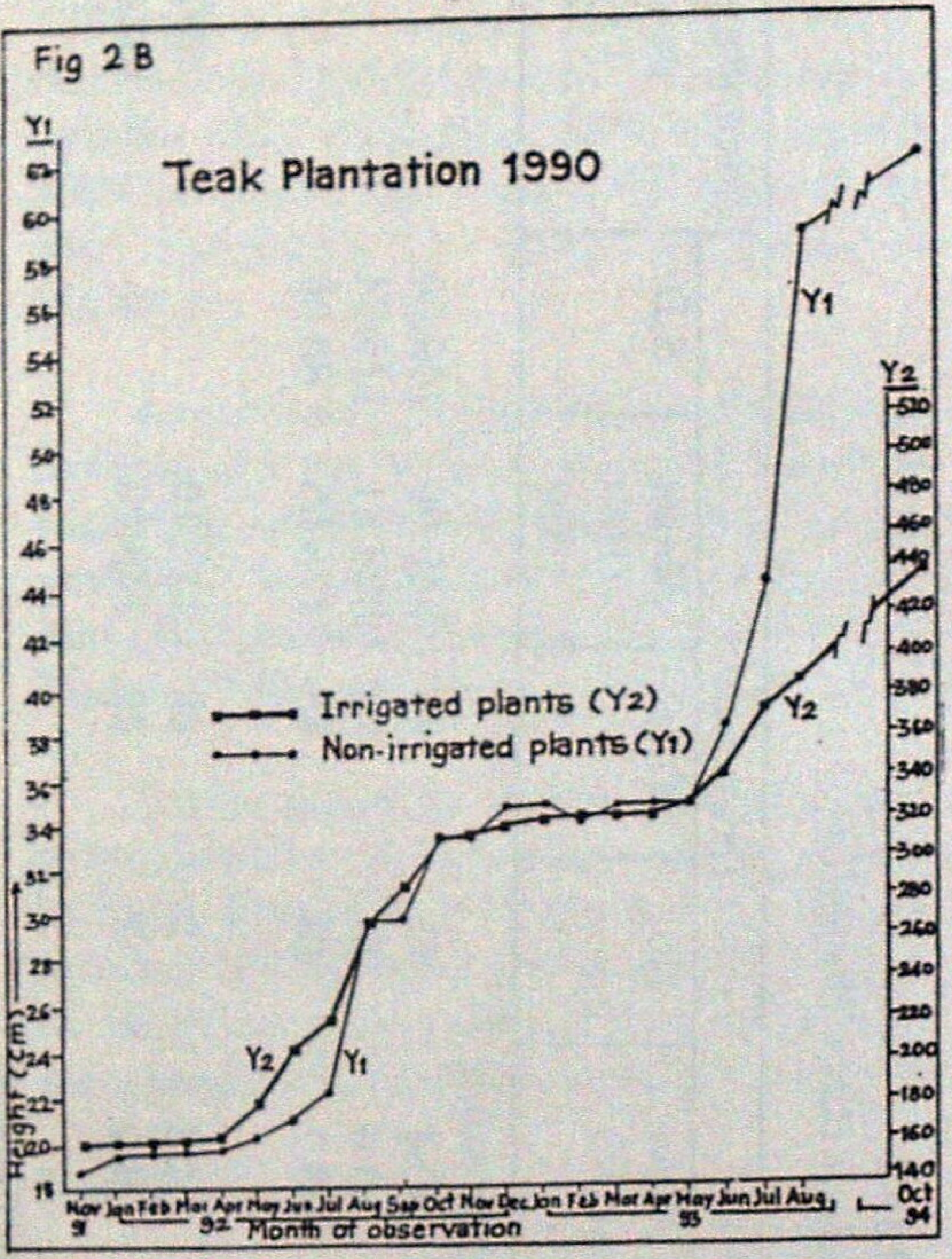


Fig. 3

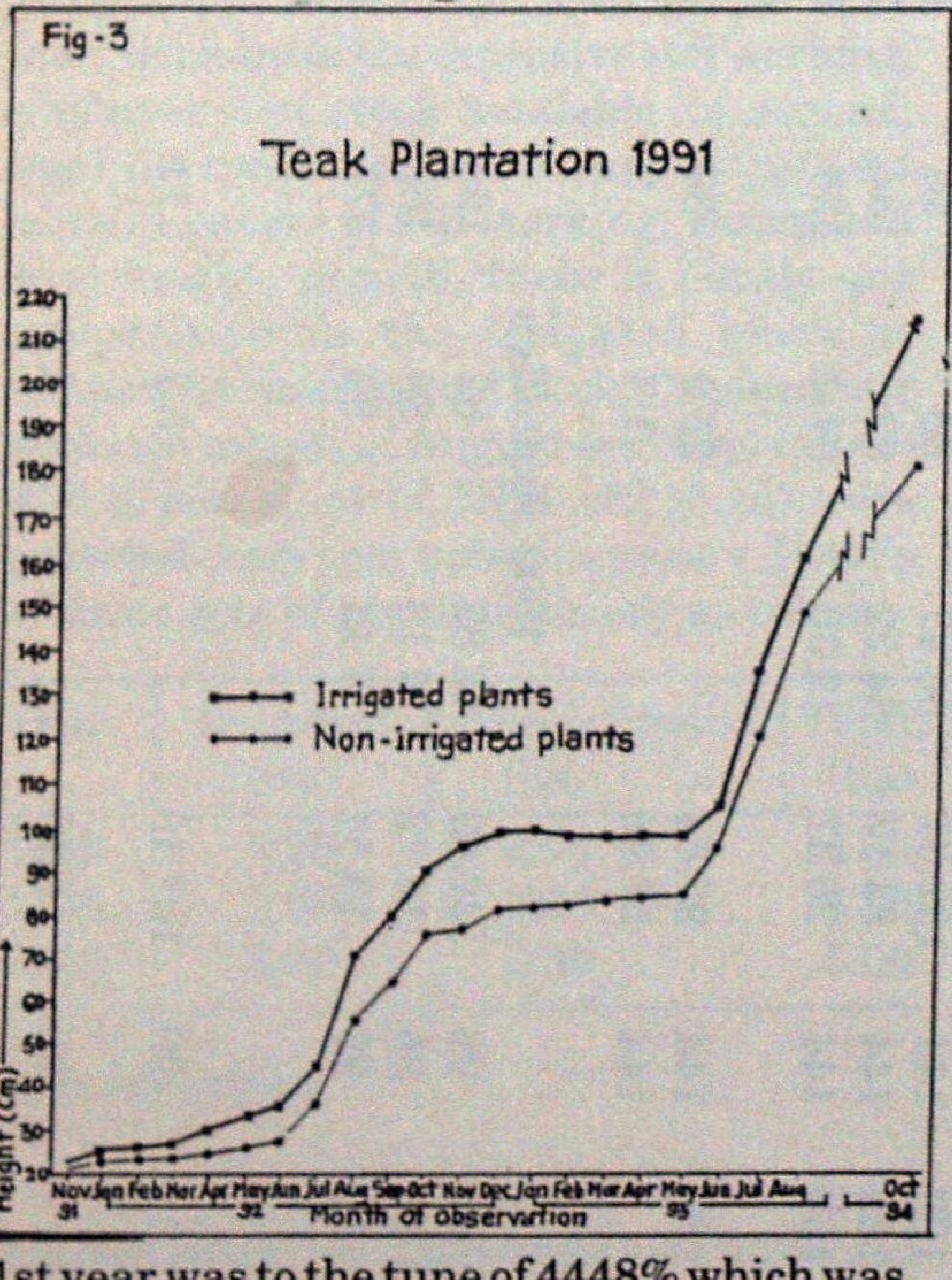
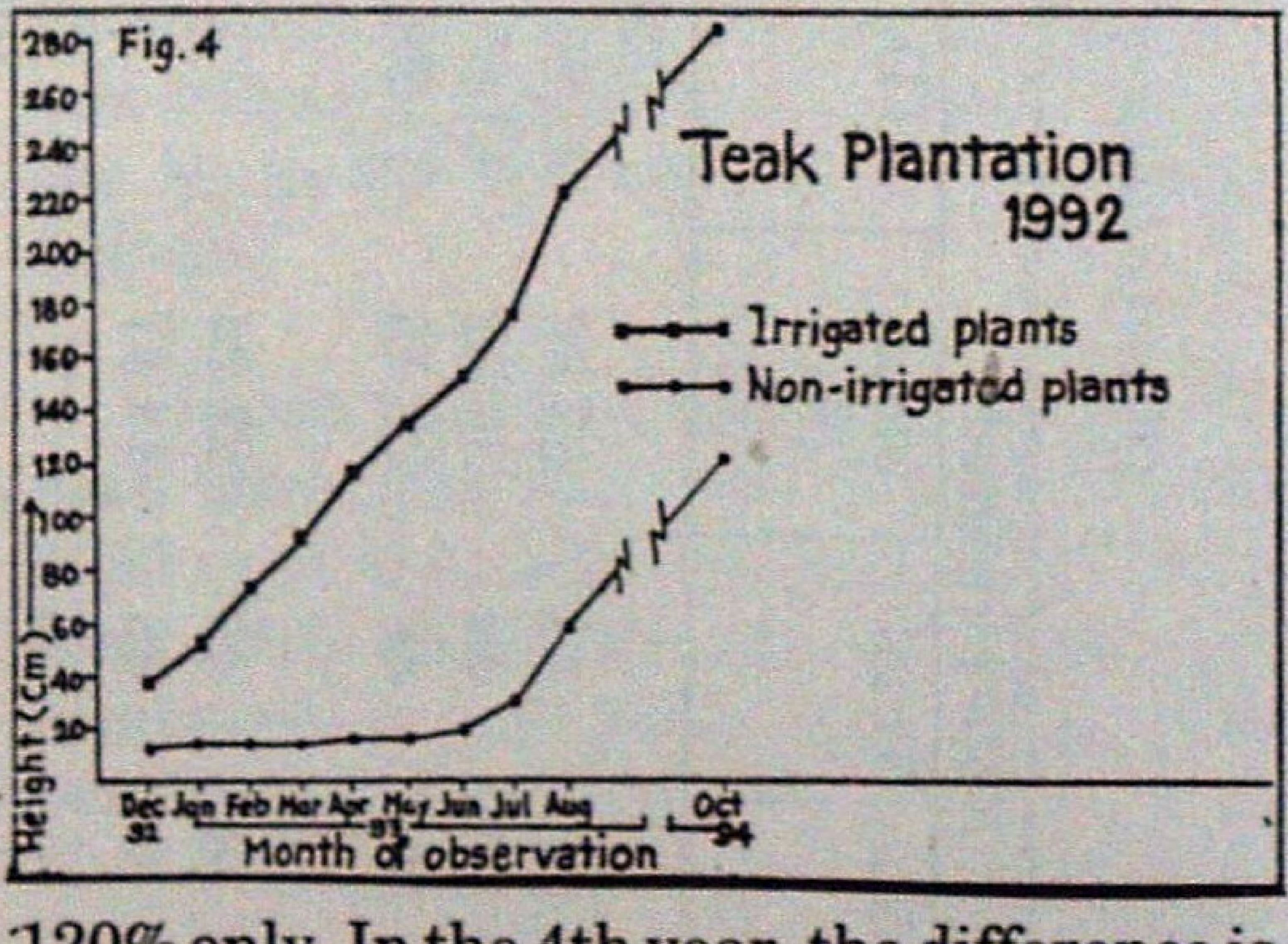


Fig. 4



1st year was to the tune of 4448% which was later on reduced to 141% and 113% in the 2nd year for 1992 and 1991 plantations respectively. For 1990 plantation, in the absence of observations in 1st and 2nd years, total percentile gain has worked out to be 1024% but in case of 1991 plantation, the difference over 2nd year is to the tune of 120% only. In the 4th year, the difference is to the tune of 397%. These are to be considered as trends, as these observations relate to limited intensity of sampling.

Table 2 is based on higher intensity of sampling and thus the results are on statistically sound footing. However,

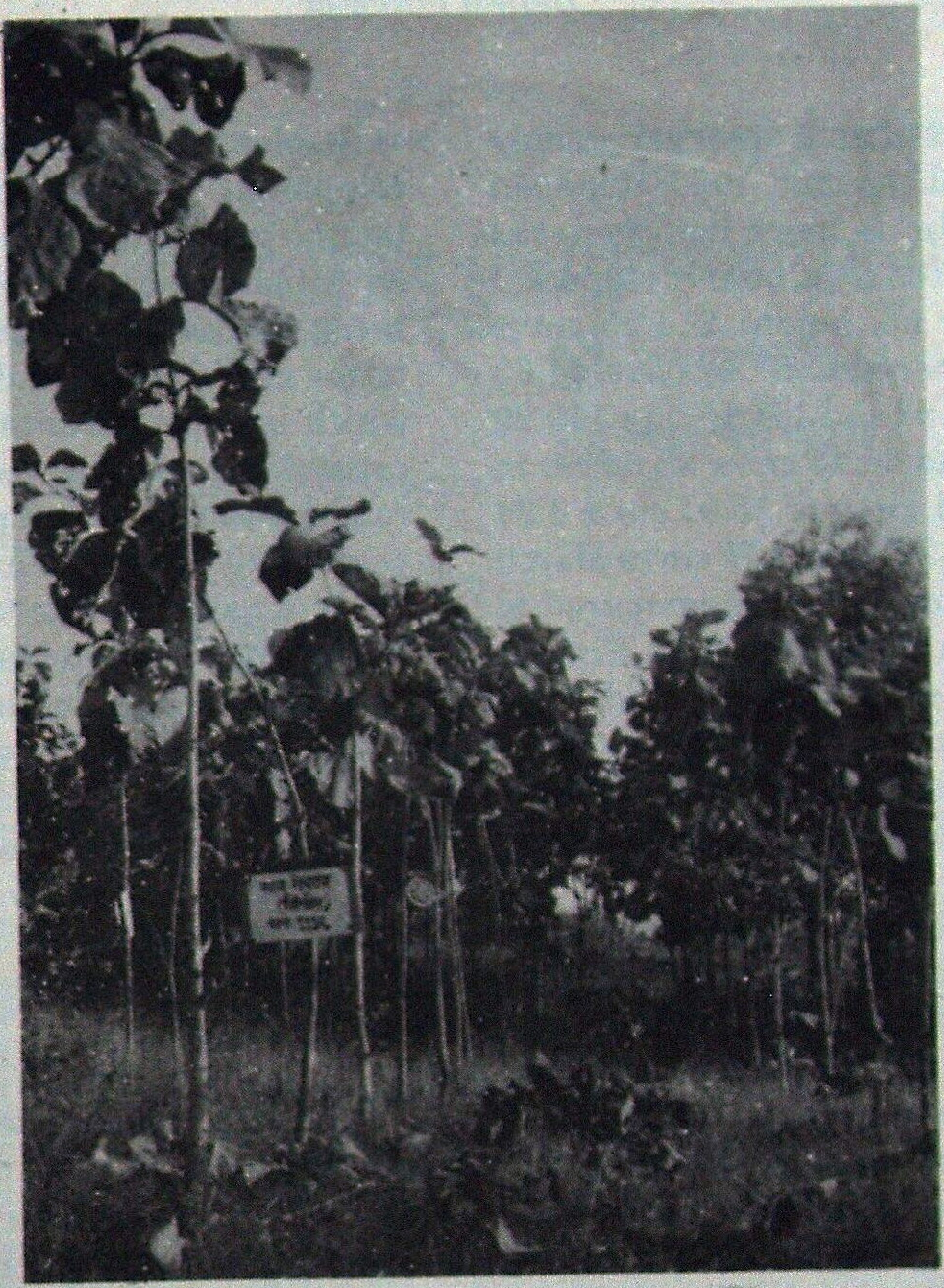
Table 2

Observations of ten percentage sampling

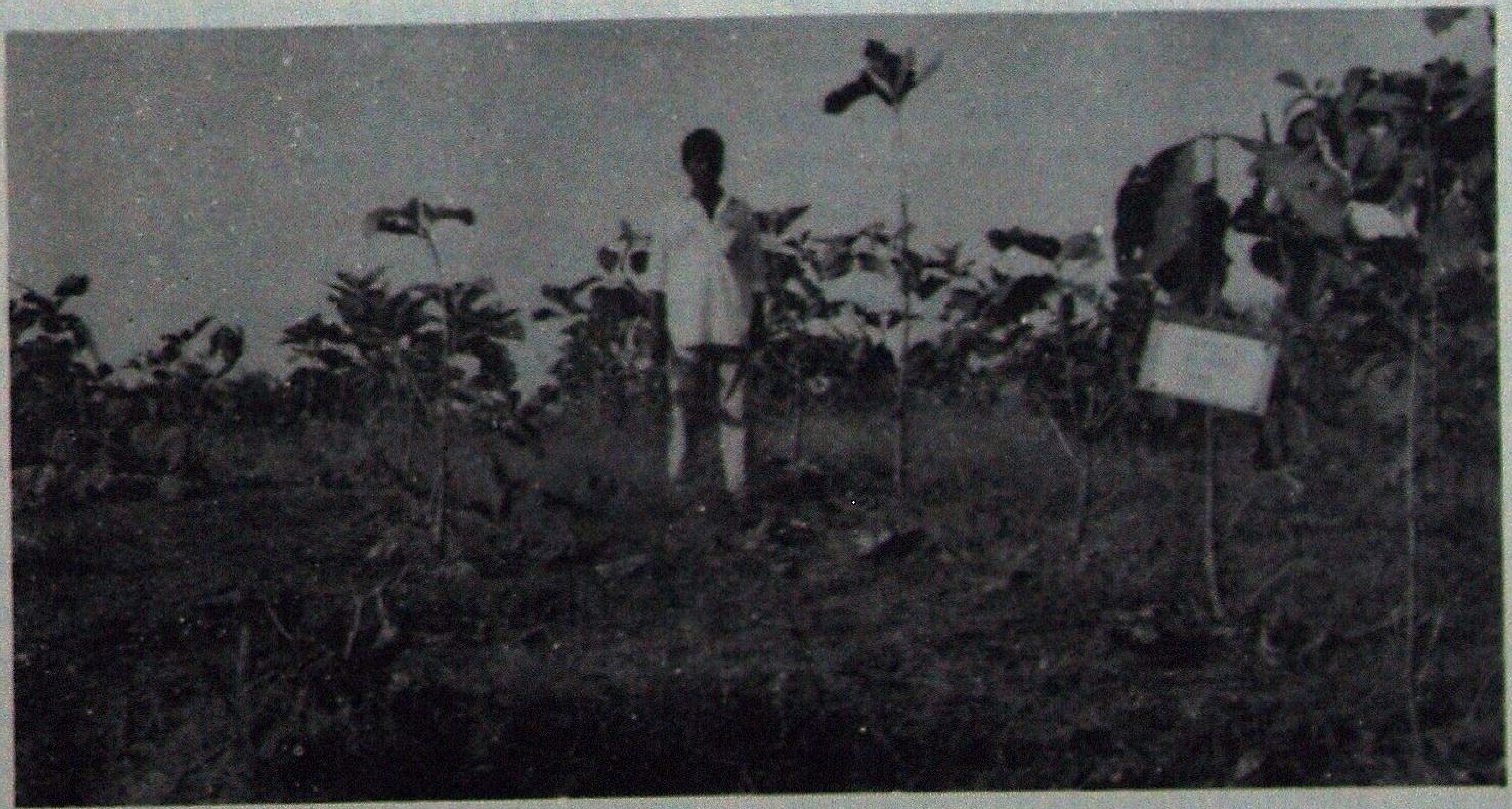
Parameter	Period	Non- irrigated				Irrigated			
		No.	Total	Mean	S.D.	No.	Total	Mean	S.D.
1990 plantation in March, 1993/ October,1994									
Height	March 93	146	1875	67.57	41.63	815	9375	214.25	92.34
	Oct. 94	114	1875	85.43	48.03	791	9375	354.15	119.20
Girth	March 93	146	1875	6.27	3.78	815	9375	15.01	4.94
	Oct. 94	114	1875	7.67	4.03	699	9375	21.16	5.62
1991 plantation in March 93/October, 1994.									
Height	March 93	503	7500	49.48	35.32	502	5000	99.78	50.50
	Oct. 94	352	7500	69.67	41.02	393	5000	154.30	82.26
Girth	March 93	503	7500	4.87	2.90	502	5000	9.10	3.66
	Oct. 94	350	7500	6.88	3.42	393	5000	13.31	5.08
1992 Plantation in March,93/October, 1994.									
Height	March 93	647	6250	15.29	6.09	688	6250	53.98	36.06
	Oct. 94	412	6250	80.79	46.08	631	6250	226.48	108.16
Girth	March 93	647	6250	-	-	688	6250	7.40	3.15
	Oct. 94	404	6250	6.60	3.05	614	6250	16.52	4.62

Irrigated Teak Plantation, 1991

Control Teak Plantaion, 1991



Irrigated Teak Plantation, 1992



Control Teak Plantaion, 1992

information is based on 2 observation only i.e. in March 1993/October, 1994. It is seen that irrigated crop is more homogeneous than the unirrigated crop, both in respect of height and girth i.e. height 214.25 cm ± 92.34 cm as compared to 67.37 cm ± 41.63 cm, during March 93 and 354.15 cm ± 119.20 cm as compared to 85.43 cm ± 48.03 cm in October 1994 and girth of 15.01 cm ± 4.94 cm compared to 6.27 cm ± 3.78 cm in March 1993 and 21.16 cm ±5.62 cm compared to 7.67 cm ± 4.03 cm in October 1994. Similar trends are also seen in 1991 and 1992 plantations. Wider variations in non-irrigated crop is mainly because of proximity of certain plants to almost perennial nallas.

In case of 1991 plantation response to irrigation has been limited which is attributed to poor status of soils in the block. Response to irrigation in 1992 plantation has been very dramatic in the 1st year but the same has tapered from the 2nd growth season onwards.

Plants have certainly benefited by irrigation and there is definite gain in height as well as in girth by the end of second year, third year and part of fourth year, as well and confirm trend observed through analysis of limited observations vide Table 1.

Figure 5 indicates spread of plants in different girth classes, as from management point of view this is important consideration. Availability of marketable pole from thinning have a direct bearing on plantation economics.

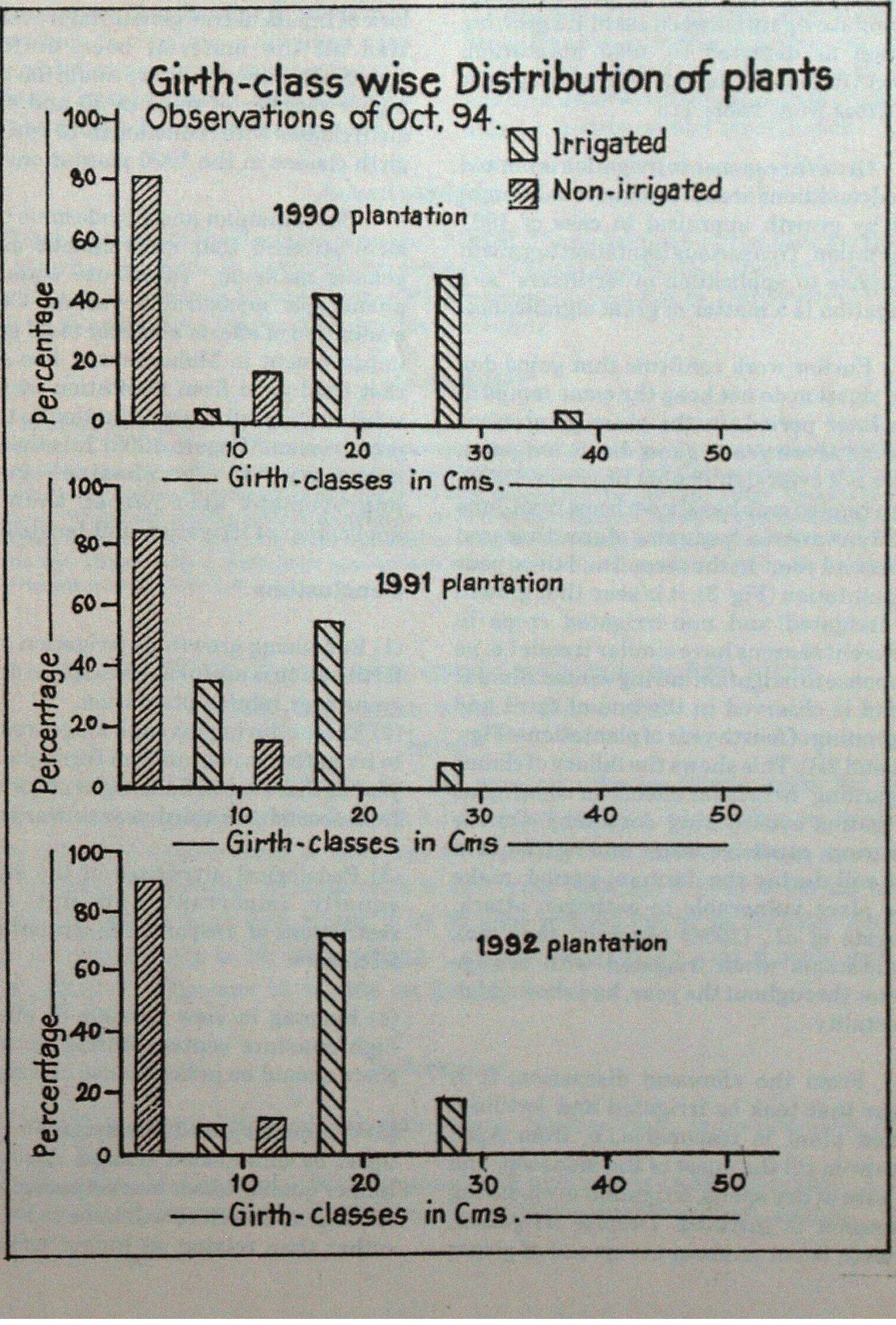
Discussion

There is a common belief that continuous addition of inputs like irrigation will result in round the year growth of the teak plants. There has been a boom of companies floating schemes for growing teak on private lands and the entrepreneurs have been making very tall claims; it is being touted that with higher inputs in terms of irrigation and fertilizers, growth which is expected from 40 to 50 year old plantation revised by conventional methods can be attained over a period of less than 6 years to 20 years with high inputs. In a case study, it has been observed that the farmers raising the irrigated teak plantations, start irrigation immediately after the withdrawal of the monsoon and continue it till the onset of next monsoon, i.e. even during the dormancy period of the teak plant (Joshi and Farooqui, 1991). Like other leaf shedding species, teak sheds all its leaves thus cannot utilize water and nutrients during this period.

During the first and second years of plantations (Fig.4) under irrigated conditions plants have continued to grow even during the dormancy period i.e. January,1993 to April/May,93 as plants in juvenile state, behave differently. But beyond this stage, growth did retard (Figs. 3 and 4). The gains due to irrigation are spectacular in the first year, however, this gain gradually tapers off.

As narrated earlier, Fig. 2 to 4 are based on limited sampling intensity and thus Table 2 need be given credence despite the fact that observations are limited i.e. March 1993 and October,1994. It will be seen that the irrigated plants have responded almost 3 times in growth over the response in non-irrigated plantations. This is in contrast to 44 times growth observed through limited observations. Judging from the response in the 3rd growing season depicted by 1991 plantation, response of plants in irrigated plantations

Fig. 5



Girth-class wise Distribution of plants
Observations of Oct. 94.
▧ Irrigated
▨ Non-irrigated
1990 plantation
1991 plantation
1992 plantation
Percentage
0
20
40
60
80
100
10
20
30
40
50
Girth-classes in Cms.

is 2½ times over that of non-irrigated. Cumulative gain between 1st to 4th growing season as depicted in 1990 plantation, growth difference is about 7 times (as against 10 times from Table 1).

Growth response to irrigation is limited if soil conditions are not conducive as brought out by growth appraisal in case of 1991 plantation. This serious limitation to growth response to application of fertilizers and irrigation is a matter of great significance.

Earlier work confirms that gains due to irrigation do not keep the same tempo in the later period. In the older plantations beyond seven years, gains due to irrigation were not even significant (Bhadran, 1959). Unirrigated crop has shown boost from June 1993 onwards i.e. beginning of growth season in second year. In the second and third year of plantation (Fig. 3), it is seen that growth in irrigated and non-irrigated crops in different seasons have similar trends i.e. no response to irrigation during winter. Similar trend is observed in the end of third and beginning of fourth year of plantations (Figs. 2A and 2B). This shows the fallacy of claims regarding beneficial effects on continuous irrigation even during dormancy. On the contrary, excessive water and nutrients in the soil during the dormant period, make the plant vulnerable to pathogen attack. Gogate *et al.*, (1995) observed that teak plantations when irrigated with sewage water throughout the year, had shown high mortality.

From the aforesaid discussion, it is clear that teak be irrigated and fertilised when plant is responsive, i.e. from April onwards till the onset of the monsoon, and in case of dry spells, irrigation even during monsoon is justified. Despite irrigation, growth is not uniform i.e. spread of plants in different girth classes and is attributed to lack of inputs in tree genetic improvement. Had all the material been uniformly genetically superior, there would have been higher number of trees in 30 and 40 cm, girth classes with reduction in 10 and 20 cm girth classes in the 1990 plantations.

Subramanian and Nicodesmus (1993) have stressed that environment as also genetic make-up contribute equally in phenotypic measurable values. Critical evaluation of efforts made for teak genetic improvement in Maharashtra, has shown that total yield from plantation increases substantially with mere selection as tool for improvement (Gogate, 1993). It is therefore, necessary to emphasize genetic improvement also rather than only application of irrigation and fertilizers.

Conclusions

(1) Enhancing growth by irrigation as also fertilization is useful as it results in definite gains over rainfed plantation.
(2) Except during juvenile stage, response to irrigation is not uniform throughout the year as there are definite signs of dormancy from second and third year onwards.

(3) Pedological attributes of the site are equally important and put severe restrictions of responses to irrigation and fertilizers.

(4) Keeping in view possible ill effects of high moisture content during dormancy, there should be judicious use of irrigation.

(5) Volumetric gain due to irrigation may be upset by diminished returns due to poor timber quality/lesser market acceptability. A balance, therefore will have to be struck rather than relying on higher volumetric

gains by maximum irrigation.

(6) Irrigation and fertilization involves high inputs which in tree crop cultivation with longer gestation period is a severe economic constrain. On this criteria also, judicious irrigation will work out to be more attractive financial proposition.

(7) Investments in genetic improvement, would lead to qualitative as also quantitative gains with limited, one time investment and thus deserves prioratisation over efforts only on environmental modification.

Acknowledgements

Thanks are due to the Regional Manager, FDCM, Thane Region for providing pertinent office records. We have to acknowledge support of Corporation field staff in recording observation during March, 93 and October, 94. Department of Statistics, University of Poona helped us in computing information and its processing.

SUMMARY

A critical assessment of series of high input teak plantations established by Divisional Manager, F.D.C.M. Ltd., Thane Division has been carried out. Application of irrigation and fertilizers have definitely shown positive response and has resulted in gains over rainfed plantations. Continuous monitoring of response to irrigation has revealed that except during juvenile stage, there is lack of response to irrigation during winter months i.e. period of dormancy. Claims of spectacular growth with higher inputs round the year made by number of agencies engaged in tree plantation ventures, are thus not supported. A judicious application of irrigation and greater emphasis on genetic improvement is thus stressed.

सिंचाई के प्रति वृद्धि प्रतिचार - एकसाल (अम्भाड़ी) सागौन रोपवन का विशेष अध्ययन

एम०जी० गोगटे, यु०एम० फारूकी व वी०एस० जोशी

सारांश

प्रभागीय प्रबन्धक, वन विभाग सहकारी प्रबन्ध लि०, ठाणे मण्डल द्वारा अधिक धन निवेशकर स्थापित किए सागौन रोपवनों की माला का समालोचनात्मक मूल्यांकन किया गया है । सिंचाई करने और उर्वरक देने का निश्चित रूप से धनात्मक प्रतिचार हुआ है और वे वर्षापोषित रोपवनों से अधिक अच्छे बने हैं । सिंचाई के प्रति प्रतिचार की निरन्तर पड़ताल करते रहने पर पता लगा है कि बाल्यावस्था को छोड़कर सर्दियों के महीनों अर्थात् सुषुप्ति काल में सिंचाई के प्रति कोई प्रतिचार नहीं होता । इस तरह वृक्ष रोपवन लगाने के कार्यों में लगे हुए अनेक अभिकरणों द्वारा पूरे वर्ष भर निवेश करते रहने से मिलने वाले उल्लेखनीय वृद्धि के दावे समर्थित नहीं होते । इस प्रकार सिंचाई को सूझ - बूझ से उपयोग करने तथा आनुवंशिक परिष्कार पर अधिक ध्यान देने पर विशेष बल दिया गया है ।

References

Bhadran, C.A.R. (1959). Irrigated teak plantation in Madras State. *Indian Forester,* **85**(6) : 321.

Joshi, V.S. and U.M. Farooqui (1991). *Irrigated teak plantations in Maharashtra - A case Study* International Teak Symposium, Thiruvananthapuram, Kerala.

Gogate, M.G., U.M.Farooqui and V.S. Joshi (1995). Sewage water as potential for the tree growth - A Study on teak (*Tectona grandis*) *Plantation. Indian Forester*, **121(6)** : 472-481.

Gogate, M.G. (1993). Tree improvement in Maharashtra with special reference to *Tectona grandis. Proc. of Workshop on production of Genetically improved planting materials for Afforestation Programme,* Coimbatore, FAO, Los Benos.

Subramanian, K.M. and A.Nicodesmus. (1993). General concepts of Tree improvement. *Proc. of Workshop on production of Genetically improved plantation materials for Afforestation Programmes.* Coimbatore. FAO, Los Benos.

Snippets

TULIPS

Hillegom, Netherlands - Flower lovers can breathe a sigh of relief. Despite the Dutch floods, the tulip harvest is safe.

"Almost 100 per cent of our tulip production is out-side of the flooding area," said Bert Nollen, marketing director at the International Flower Bulb Center.

The tulip, ultimate symbol of the Netherlands, is cultivated in sandy or clay like soils concentrated in the country's northwestern regions, about 160 km from the flooding areas in the Gelderland and Limburg regions.

The Netherlands produces more than 70 per cent of the world's tulip bulbs, about 3.1 billion, and the perennial bulbs are exported to 80 countries.

Source : *Ceres,* Vol. 27, No. 3

A STUDY ON VOLUME ESTIMATION FOR INDIAN TEAK

S.K. CHAKRBARTI AND K.S. GAHARWAR

Forest Survey of India, Dehra Dun (U.P.)

Introduction

Teak (*Tectona grandis*) is one of the most important species of the world. It is grown practically in all the tropical countries. Natural distribution of this species is in South and South-East Asian countries. It has been raised by plantation in vast areas in these countries and other tropical or sub-tropical countries like East and West African countries, Caribbean and South and Central American countries.

In India, which is one of the major teak producing countries, its natural zone of distribution is discontinuous and is mostly confined to the peninsular region below 24 degree latitude. The localities where most important teak forests are found are Madhya Pradesh, Maharashtra, Tamil Nadu, Karnataka and Kerala besides Uttar Pradesh, Gujarat, Orissa and Rajasthan (Troup, 1921). It has also been raised, mainly by plantation, in Assam, Dadra and Nagar Haveli, Meghalaya, West Bengal, Uttar Pradesh and Haryana.

Study Coverage

The source of data are the forest inventory surveys carried out by Forest Survey of India at various points of time covering the areas of Andhra Pradesh, Assam, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Meghalaya, Rajasthan, Uttar Pradesh, West Bengal and Dadra and Nagar Haveli.

Scope of Study

Keeping in view the utility and commercial importance of the species, scattered information on volume equations in different Forest Inventory Reports of the Forest Survey of India (FSI) and its predecessor Organisation, Pre-Investment Survey of Forest Resources (PISFR) have been collected and compiled. For estimation of growing stock, General and Local Volume Equation for each major pre-dominant and rest of species for each inventory surveys are derived. For Teak, the types of Multiple Regression Equations which have been found best fit for deriving the Local Volume Equations from the General Volume Equations along with survey areas are as follows :

(1) $V = a + bD^2$ (Andhra Pradesh, Karnataka, Madhya Pradesh and Meghalaya)

(2) $V = a + bD + cD^2$ (Andhra Pradesh, Madhya Pradesh, Maharashtra, Rajasthan and West Bengal)

(3) $V = a + bD + cD^2 + dD^3$ (Assam, Madhya Pradesh and Uttar Pradesh)

(4) $V = a + b\sqrt{D + cD^2}$ (Madhya Pradesh and Uttar Pradesh)

(5) $\sqrt{V} = a + bD + c\sqrt{D}$ (Dadra and Nagar Haveli, Gujarat, Madhya Pradesh and Maharashtra)

(6) $\sqrt{V} = a \quad bD$ (Maharashtra)

Where D = Diameter (over bark) in metre
V = Volume (under bark) in m^3
a, b, c, d are statistical constants

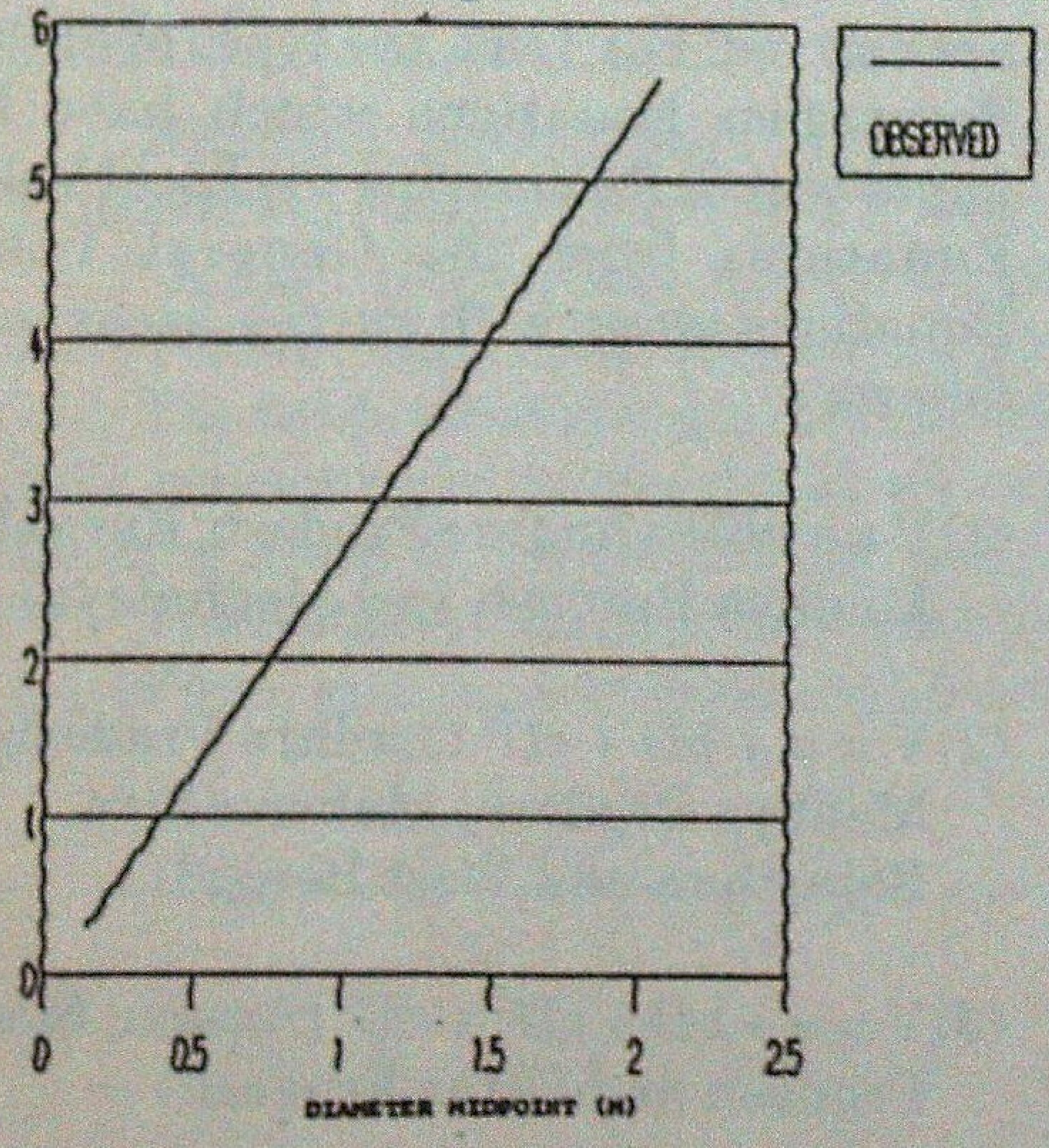
The local volume equations compiled for Teak from various Forest Inventory Surveys vary from area to area. An attempt has been made in this study as a test case to combine these local volume equations into one single volume equation.

In the present study local volume equations, which have been derived from large number of observations (varying from 30 to 2000), have been used to calculate volume factors for different diameter classes by substituting the values of D (diameter mid point) in each of the local volume equations. Average volume corresponding to each diameter mid point has been estimated from the volume table. A statistical relationship of these average volumes (dependent variable) corresponding to the mid point of each diameter class (independent variable) has been established.

Presentation and Analysis of Data

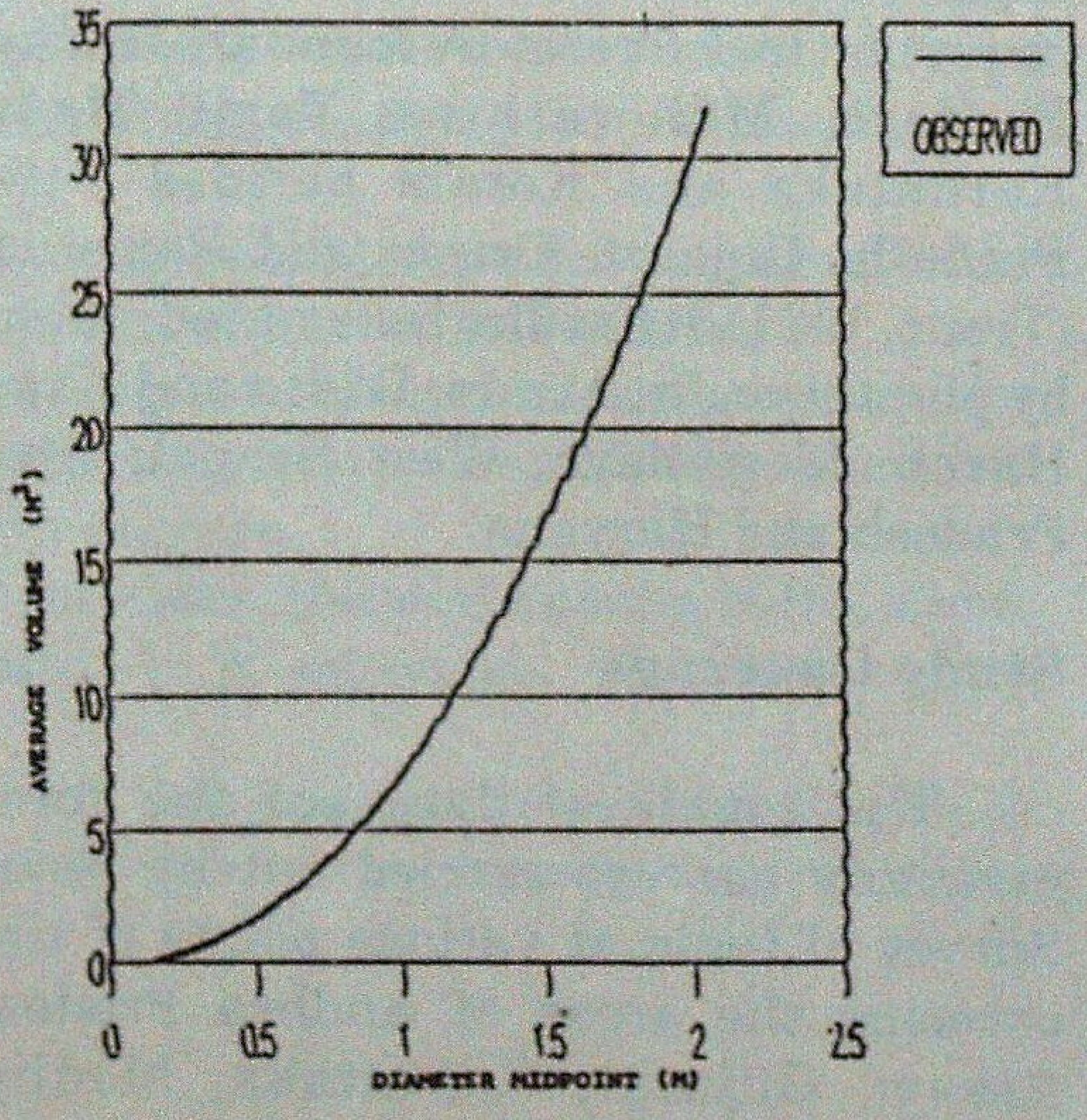
For the present study, 20 local volume equations on Teak from different inventory reports have been collected and compiled. Volume factors for diameter classes (in cm) 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80, 80-90, 90-100, 100-110, 110-120, 120-130 have been calculated for each of the local volume equations by taking the mid point of the diameter class i.e. 15, 25, 35, 45, 55, 65, 75, 85, 95, 105, 115, 125 (in cm). These volume factors are presented in Table 1. Average volume corresponding to the same diameter mid point has also been estimated and is presented in the last row

Fig. 1



Scatter diagram between Square-root of Average Volume and Diameter Mid-point.

Fig. 2



Scatter diagram between Average Volume and Diameter Mid-point.

Table 1

Volume table for Indian Teak based on the local volume equations derived from FSI Inventory Reports

Name of State UT/ District Forest Division/ Forest Circle	Diameter Class (cm)											
	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	110-120	120-130
	Diameter Mid-Point (m)											
	0.15	0.25	0.35	0.45	0.55	0.65	0.75	0.85	0.95	1.05	1.15	1.25
1	2	3	4	5	6	7	8	9	10	11	12	13
Andhra Pradesh												
1. Mehboobnagar Forest Division	0.041	0.267	0.605	1.056	1.62	2.297	3.087	3.99	5.005	6.133	7.374	8.728
2. Adilabad District	0.095	0.312	0.662	1.148	1.768	2.522	3.412	4.435	5.594	6.887	8.315	9.877
Assam												
3. Assam Survey (15 Districts)	0.101	0.472	1.176	2.204	3.546	5.191	7.13	9.352	11.848	14.608	17.621	20.879
Dadra and Nagar Haveli; Gujarat; Madhya Pradesh and Maharashtra												
4. Dadra and Nagar Haveli Survey; Surat circle of Gujarat; Khargone, Khandwa, Dewas, Jhabua, Indore and Dhar Districts of Madhya Pradesh and Mewasi Forest Divn., Dhulia, Nasik, Thane and Raigad Districts of Maharashtra	0.075	0.34	0.76	1.318	2.006	2.816	3.746	4.791	5.959	7.217	8.595	10.081
Karnataka												
5. Chickmgalur, Hassan and Shimoga Districts	0.213	0.439	0.777	1.228	1.792	2.469	3.259	4.162	5.177	6.305	7.546	8.9
Madhya Pradesh												
6. Balaghat, Seoni and Mandla Distts.	0.139	0.461	0.965	1.647	2.508	3.546	4.761	6.154	7.723	9.468	11.39	13.488

(Contd...)

1	2	3	4	5	6	7	8	9	10	11	12	13
7. Rajnandgaon and Durg Distt.	0.098	0.358	0.81	1.467	2.341	3.443	4.784	6.378	8.235	10.367	12.786	15.504
8. Bilaspur District	0.105	0.32	0.644	1.076	1.615	2.262	3.017	3.881	4.851	5.93	7.117	8.412
9. Indore Catchment Mandsour, Ratlam, Ujjain, Shahjapur and Raigarh Distt.	0.72	0.243	0.547	0.984	1.552	2.253	3.086	4.051	5.149	6.379	7.741	9.235
10. Raipur District	0.104	0.427	0.967	1.678	2.516	3.434	4.387	5.33	6.217	7.003	7.643	8.091
Maharastra												
11. Ballarshah Catchment-Chanda Priority-I	0.092	0.356	0.822	1.49	2.361	3.435	4.71	6.188	7.869	9.751	11.836	14.123
12. Sondad Catchment Bhandara Distt.	0.083	0.3	0.644	1.115	1.714	2.44	3.294	4.275	5.383	6.619	7.982	9.473
13. Wadsa Catchment-Chanda Priority - II	0.077	0.285	0.624	1.095	1.697	2.43	3.295	4.29	5.418	6.676	8.066	9.587
14. Melghat Forest Divn.	0.106	0.403	0.898	1.591	2.483	3.573	4.861	6.347	8.031	9.914	11.995	14.274
Meghalaya												
15. Whole Meghalaya Survey	0.131	0.524	1.114	1.89	2.883	4.062	5.438	7.011	8.78	10.745	12.907	15.266
Rajasthan												
16. Udaipur Forest Division	0.072	0.243	0.547	0.984	1.552	2.253	3.086	4.051	5.149	6.379	7.741	9.235
17. Southern and Eastern parts	0.061	0.158	0.294	0.469	0.683	0.936	1.228	1.56	1.93	2.34	2.789	3.276
Uttar Pradesh												
18. Hill and Tarai Region	0.144	0.501	1.127	2.035	3.235	4.74	6.562	8.712	11.203	14.046	17.252	20.835
19. Southern Region	0.115	0.322	0.59	0.923	1.324	1.795	2.335	2.946	3.628	4.38	5.204	6.1
West Bengal												
20. Darjeeling and Kalimpong Division	0.062	0.277	0.631	1.126	1.76	2.535	3.449	4.504	5.698	7.033	8.508	10.122
Average Volume	0.993	0.3504	0.7602	1.3267	2.0478	2.9216	3.9464	5.1204	6.4424	7.909	9.5204	11.274

Table 2

Comparison of Observed and Expected Values

Diameter Class (cm)	Mid Dia Class (m)	Calculated Average (m^3)	Expected Volume (Equation 1) (m^3)	Expected Volume (Equation 2) (m^3)	Percentage Differences from calculated values	
					Equation 1	Equation 2
10-20	0.15	0.0993	0.0924	0.1791	7	-80
20-30	0.25	0.3504	0.3411	0.3902	3	-11
30-40	0.35	0.7602	0.7468	0.7629	2	0
40-50	0.45	1.3267	1.3094	1.2974	1	2
50-60	0.55	2.0478	2.029	1.9936	1	3
60-70	0.65	2.9216	2.9055	2.8515	1	2
70-80	0.75	3.9464	3.9389	3.8712	0	2
80-90	0.85	5.1204	5.1293	5.0525	0	1
90-100	0.95	6.4424	6.4767	6.3955	-1	1
100-110	1.05	7.909	7.981	7.9003	-1	0
110-120	1.15	9.5204	9.6422	9.5667	-1	0
120-130	1.25	11.2743	11.4604	11.3949	-2	-1
130-140	1.35	13.169	13.4356	13.3848	-2	-2
140-150	1.45	15.5696	15.5676	15.5364	0	0
150-160	1.55	17.8765	17.8567	17.8497	0	0
160-170	1.65	20.3459	20.3026	20.3247	0	0
170-180	1.75	22.9786	22.9056	22.9614	0	0
180-190	1.85	25.7753	25.6654	25.7598	0	0
190-200	1.95	28.737	28.5822	28.72	1	0
200-210	2.05	31.8639	31.656	31.8418	1	0

of this table. The scattered diagrams between Square root of the Average volume and corresponding diameter mid point has been presented in Fig. 1 and between diameter mid point and average volume is presented in Fig. 2. For this purpose observations upto diameter class 200-210 (in cm) have been considered. It may be seen from Fig. 1 that there exists a linear relationship between square root of average volume and diameter mid point. Fig 2 shows that a parabolic relationship exists between average volume and diameter mid point.

In view of the above facts an attempt has been made in this study to fit the following two regression equations :

(1) $\sqrt{V} = a + bD$
(2) $V = a + bD + cD^2$

Where a, b and c are constants
V = Volume in m^3 (under bark)
D = mid point of diameter class in m

Using the method of Least Squares the regression equations have been derived and the two equations come out to be

(1) $\sqrt{V} = -0.1163 + 2.8013D$

(2) $V = 0.1657 - 1.1235\,D + 8.0855\,D^2$

A comparison of the calculated average volume and the expected average volume obtained from both the equations is presented in Table 2. It is seen from this Table that the difference between the calculated and expected values is below 1% for most of the entries in case of equation (1) and may be considered as negligible. In case of equation (2) the percentage difference is more in lower diameter classes (i.e. 10-20 and 20-30 cm) and as diameter increases the difference becomes 0.

The determination coefficient (R^2) of regression equation (1) comes out to be 0.99993 which justifies the linearity of the relationship. Also the standard error of the estimate works out to be 0.0056.

There may be cases that fit can be bad with a high value of R and it can also happen that the fit is good and R is low. Numerous measures other than R can be considered (Anon., 1980). The most used are the residual standard deviation, residual coefficient of variation, aggregate deviation and average deviation.

For both the fitted equations the above measures were calculated and are presented below :

	Equation 1	Equation 2
(1) Residual Standard Deviation	1.0932	0.7305
(2) Residual Coefficient of Variation	0.0959	0.0641
(3) Aggregate Deviation	0.000045	0.000001
(4) Average Deviation	0.006085	0.00443

The above analysis reveals that equation (2) is the best fit.

Conclusion

It has been found that different types of local volume equations for teak exist for different forest areas but as per the findings of the present study for the country as a whole, the volume of teak may be estimated by using equation (2). However, for lower diameter classes (up to 30 cm) equation (1) can also be used.

Acknowledgements

We are grateful to Dr. S.N. Rai, Director and Shri M.M. Harbola, Joint Director, Forest Survey of India, Dehra Dun for providing encouragement and guidance.

SUMMARY

The Forest Survey of India has been carrying out inventory surveys for estimating the growing stock of various species and has developed a number of local volume equations based on ground inventory. An effort has been made to establish statistical relationship between average volume and diameter mid-point for country as a whole. Two relationships have been established by using Method of Least Squares. One is linear and the other is parabolic relationship. Volume of teak can be estimated by using parabolic relationship. However, for lower diameter classes (upto 30 cm) linear relationship can also be used to calculate the volume.

भारतीय सागौन के आयतन का अनुमान करने विषयक अध्ययन

एस० के० चक्रवर्ती व के० एस० गहरवार

सारांश

भारत का वन सर्वेक्षण विभाग विभिन्न जातियों के वनसछ वनों का अनुमान लगाने के वानिकी सर्वेक्षण कार्यों में लगा हुआ है और भूमि की वृक्ष तालिकाओं के आधार पर उसने अनेक स्थानीय आयतन समीकरण विकसित किए हैं । पूरे देश के लिए भी औसत आयतन और मध्य बिन्दु व्यास के दरम्यान सांख्यकीय सम्बन्ध स्थापित करने का प्रयास किया गया है । अल्पतम वर्ग विधि अपनाकर दो सम्बन्ध स्थापित किए गए हैं । एक रेखीय सम्बन्ध और दूसरा परावलयी सम्बन्ध । परावलयी सम्बन्ध उपयोग में लाकर सागौन के आयतन का अनुमान लगाया जा सकता है । तथापि, छोटे व्यास (30 से० मी० तक के) श्रेणियों के लिए आयतन की गणना करने के लिए रेखीय सम्बन्ध भी उपयोग में लाया जा सकता है।

References

Anon. (1980) Forest Volume Estimation and yield Prediction. Vol. 1 - Volume Estimation. Forestry Paper 22/1, FAO.

Anon. (1971-95). *Report on Forest Resources Survey* , Forest Survey of India of :

(i) Adilabad (1977); Mehboobnagar Forest Division (1971), Andhra Pradesh.
(ii) Assam State (1995).
(iii) Surat Circle (1981), Gujarat.
(iv) Shimoga (1987), Chickmagalur and Hassan (1988), Karnataka.
(v) Balaghat, Mandla and Seoni (1981); Rajnandgain and Durg (1985); Indore, Mandsaur, Ratlam, Khandwa, Khargone, Shahjapur, Rajgarh, Dewas, Jhabua, Ujjain and Dhar (1986); Raipur (1986), Madhya Pradesh.
(vi) Ballarshah Catchment (1976); Sondad Catchment - Bhandra (1977); Wadsa Catchment - Chanda (1977); Melghat (1982); Mewasi Division (1982); Dhulia (1988); Nasik, Thane & Raigarh (1990), Maharashtra.
(vii) Maghalaya State (1979),
(viii) Udaipur Division (1979); Southern & Eastern Distts.(1988), Rajasthan.
(ix) Tarai Region (1986; Hill Region (1987); Southern Region (1987), Uttar Pradesh.
(x) Darjeeling & Kalimpong Divisions (1987), West Bengal and
(xi) Dadra & Nagar Haveli (1991).

Troup, R.S. (1921). *The Silviculture of Indian Trees*.

EFFECT OF TEMPERATURE AND RELATIVE HUMIDITY ON GRAFTING AND BUDDING OF TEAK (*TECTONA GRANDIS* LINN. F)

D.P. UNIYAL AND M.S. RAWAT

Division of Genetics and Tree Propagation,
Forest Research Institute, Dehra Dun (India)

Introduction

In the genetic improvement of forest tree species vegetative propagation methods assume great importance as it enables the tree breeder to assemble the selected clones in the seed orchard to achieve self-sufficiency in seed and other requirement of reproductive material. The most important challenge is to identify and standardise the most efficient and economical vegetative method, most suited and successful for the species and location specific environment. In teak improvement programme of Indo-Danish Project grafting and budding trials were carried out in the field based on the past experience of authors. In this paper, it is proposed to present the near-perfected vegetative propagation technique under field condition for teak with special reference to Dehra Dun as it varies from place to place. In case of Andhra Pradesh the most suitable time for grafting is October-November and February-March (Krishnamurthy, 1989) while in Malleswarum it is January to April (Reddy *et al.*, 1989). In Arunachal Pradesh March and May were found to be the best period of budding to semi-evergreen and deciduous trees (Beniwal, 1989).

Materials and Methods

Scion material was collected from plus trees and grafted on 1-2 year old stock. The methods used were patch budding and cleft grafting. The scions were mostly from one year old branch cuttings from the middle portion of the crown having dormant buds. The bud and cleft grafting was carried in field from 1986 to 1989 spreading over to four months i.e. March to June. No special treatments were given except watering the grafts regularly twice a day. During this experiment stock between 1 to 1.5 cm diameter class was used. It was observed that the thickness of stock is most important in case of patch budding and cleft grafting as the matching of cambium is essential. Stock of larger diameter can also be used but they demand more labour, material and time to work upon, hence slow down the speed of work.

Results

The data presented in Table 1 clearly indicates that the patch budding can be started right from March with 40 to 90 per cent success, while cleft grafting gives the desired results, in April and May with

Table 1

Effect of temperature and humidity on the success of patch budding and cleft grafting in Tectona grandis

Years	Weather and success % data	March	April	May	June
1986	Av. Temp. ⁰C	18.0	22.6	23.4	26.2
	Av . RH(%)	68.0	61.5	62.0	69.0
	Success (%) patch budding	50.0	90.0	80.0	10.0
	Success (%) cleft grafting	40.0	80.0	90.0	25.0
1987	Av Temp. ⁰C	18.7	22.5	22.9	27.3
	Av. RH (%)	66.0	59.5	59.5	62.5
	Success (%) patch budding	60.0	80.0	90.0	09.0
	Success (%) cleft grafting	35.0	90.0	95.0	30.0
1988	Av. Temp.⁰C	17.5	24.1	26.7	26.7
	Av. RH(%)	70.0	61.5	57.0	65.5
	Success (%) patch budding	50.0	60.0	70.0	10.0
	Success (%) cleft grafting	25.0	80.0	80.0	25.0
1989	Av. Temp.⁰C	17.6	21.3	26.2	26.0
	Av. RH (%)	64.5	55.0	45.5	69.0
	Success (%) patch budding	40.0	80.0	90.0	20.0
	Success (%) cleft grafting	40.0	85.0	90.0	35.0
Av. success (%) of four years.	Av. Temp.⁰C	17.95	22.62	24.85	26.55
	Av. RH(%)	67.12	59.37	56.00	66.62
	Patch budding	50.00	77.50	82.50	12.25
	Cleft grafting	35.00	83.75	88.75	28.75

success of 80 to 95 per cent. Temperature and humidity are two important environmental factors which regulate the success of both the methods. Low temperature i.e. below 20⁰C inhibits the sprouting causing low success.

Discussion

From the results presented in table it is quite evident that both cleft grafting and patch budding can be carried out with a high percentage of success if these are done under the climatic condition when average temperature is 21.3° to 26.70°C and relative humidity 45.5 to 60 per cent which prevails in Dehra Dun during the month of April and May, this may vary from year to year. The success achieved in case of cleft grafting was 80-95% while in case of patch budding it was 60-90%. Before and after this period the success was not very encouraging however, in case of patch budding, 50 per cent success was obtain in the month of March which is quite satisfactory.

This clearly indicates that apart from skill the time factor definitely has a controlling role in the success of the operation done. If the temperature is low, then the desired the bud or scions may remain dormant and some dry up. If the temperature and humidity are higher the rotting of scion and bud material was observed. However in some cases the dormant bud may sprout next year but the scion generally dries. If the conditions of temperature and humidity are ideal the sprouting takes place within a week although it various from clone to clone.

Keeping this in view it will be now clear why April and May were found most suitable months for these operations. If such conditions can be created in a glasshouse the work period can be prolonged but for large scale operations the work has to be carried out in field so the need to find out the optimum time period becomes paramount.

In cleft grafting the stock is cut to fit in the scion and binding material and polythene tape, to check the evaporation from the cut surface, is used. This takes at least 12-15 minutes to make one graft. If the stock is thinner the cost will increase further more in terms of labour, time and material. If the union does not take place the labour goes waste and stock is deformed.

In patch budding only a small portion of bark is removed from the internode and after fixing the bud only polythene tape is required to keep it in position and protect from desiccation and it hardly takes 3-6 minutes to complete the operation and also in terms of reproductive material. Hence it is easier and more economical as compared to cleft grafting.

Pooling together the data for four consecutive years it is clear that temperature and relative humidity do play an important role in the success of the grafts. It may also be noted that bud grafting can be started earlier than the cleft grafting.

SUMMARY

Cleft grafting and Patch budding are highly successful methods for clonal propagation of Teak provided that work is carried out at 21.3° - 26.3°C temperature and 45.5 - 62 per cent relative humidity. Cleft grafting is less economical method in terms of time, material and work as compared to patch budding which is far more easier and cheaper technique. The work is generally carried out in open field condition and for Dehra Dun, April and May were found most suitable period to obtain the maximum success. The percentage of success can be increased by the use of greenhouse or Mist chamber.

सागौन (*टैक्टोना ग्रांडिस* लि० वत्स) के कलम उपरोपने में और कलिका बांधने पर तापमान और आपेक्षिक नमी का प्रभाव

डी०पी० उनियाल व एम०एस० रावत

सारांश

दीर्णिका उपरोपण और पट्टी कलिका बंधन सागौन के कृन्तक प्रवर्धन की बहुत सफल रहने वाली विधियों में से है बर्शते कि यह कार्य 21.3° सें० से 26.7 ° सें० तापमान और 45.5-62% आपेक्षिक नमी पर किया जाए । समय, वस्तु और कार्य के विचार से पट्टी कलिका बंधन की तुलना में दीर्णिका उपरोपण की विधि आर्थिक दृष्टि से कम लाभकारी रहती है क्योंकि कलिका बन्धन उससे अधिक सरल और सस्ती विधि है । यह कार्य प्रायः खुली क्षेत्र दशाओं में किया जाता है और देहरादून में इसमें अधिकतम सफलता पाने के लिए अप्रैल और मई सबसे अधिक उपयुक्त पाए गए हैं । हरित ग्रह या धुंध प्रकोष्ठ उपयोग में लाकर सफलता प्रतिशत और भी बढ़ाया जा सकता है ।

References

Beniwal, B.S (1989). Field grafting trials on evergreen, semi-evergreen and deciduous timber species. *Proc. Seminar on Vegetative Propagation,* Institute of Forest Genetics and Tree Breeding, Coimbatore, July 27-28.

Krishnamurthy, A.V.R.G. (1989). Vegetative Propagation; problem and perspectives in genetic improvement of Forest trees.*Proc. Seminar on Vegetative Propagation*, Institute of Forest Genetics and Tree Breeding, Coimbatore, July 27-28.

Reddy Yellapa, A.N., M.H., Swaminathan and G.V. Sugur (1989). Vegetative Propagation of Tree species. *Proc. Seminar on Vegetative Propagation,* Institute of forest Genetics and Tree Breeding, Coimbatore, July 27-28.

A NOTE ON HEARTWOOD PROPORTION AND WOOD DENSITY OF 8-YEAR-OLD TEAK

K.M. BHAT

Division of Wood Science,
Kerala Forest Research Institute, Peechi (Kerala)

Introduction

Teak (*Tectona grandis*) is one of the most preferred species in intensive plantation forestry. Knowledge of wood properties of 8-year-old teak is essential for the efficient utilisation of wood from second mechanical thinning and early tree harvesting in the recently launched commercial and intensive forestry schemes in India. While estimation of heartwood proportion helps assessing the differences in durability and decorative value, density (or specific gravity) determination can be rapid and simple method of an early assessment of timber strength and pulp yield.

The present study attempts to answer the two major questions: firstly, whether 8-year-old teak is inferior in wood quality to mature or older trees in terms of heartwood content and wood density and secondly, whether faster growth affects these wood quality parameters.

Materials and Methods

As Nilambur (Kerala) is one of the most important locations of teak plantations in India, trees were sampled in 8-year-old plantations of the Nilambur Forest Division. Sampled trees extended over an area of 2,500 ha of assorted age, part of which represented the second rotation plantations. About 10 cm thick cross sectional discs were cut at breast height (BH) level (1.37 m from the stump level) from 102 trees. As per the experimental design of a defoliation study (Nair *et al.*, 1985), these trees represented two populations, viz. protected from insect defoliation for the previous four years and unprotected as control plantations. Two stands represented each population with the replica of 2 plots each.

Ring width was measured from two opposite radii of the cross sectional discs in the laboratory, covering the eccentricity, if any, to determine the ring width of individual growth rings with the help of a stereo microscope. Whole discs were used to determine basic wood density (o.d. weight to green volume) by gravimetric method. To estimate the heartwood percentage by volume, heartwood area and disc area were calculated by measuring four radii at right angles to one another and four measurements were averaged for each disc.

Results and Discussion

The mean ring width values indicate that growth rate decreases with age and the ring in 8-year-old wood is considerably greater than in the wood of older trees (Table 1).

Table 1

Comparison of certain wood properties of 8-year-old teak with published values in older trees

Property	8 yr old		27-yr old *	51-52-yr old **
	Mean	CV%	Avg.	Avg.
BH diameter (cm)	10.5	18.1	-	35
Ring width	5.7	43.8	4.3	3.3
Density (kg/m^3)	582.1	7.0	551	612
Heartwood %	30.1	37.6	-	76.6

* Sanwo (1987), ** Bhat *et al.* (1985).

Table 2

Correlation coefficients for interrelationships between certain properties

Diameter *vs* Heartwood%	0.456**
Ring width *vs* Heartwood %	0.728 **
Diameter *vs* Density	0.031^{ns}
Ring width *vs* Density	0.040^{ns}
Density *vs* Heartwood %	-0.127^{ns}

Significant at 1% level; ^{ns} Not significant.

Heartwood percentage : The mean heartwood content is 30% which is less than half the value reported for 51-52-year-old trees sampled from the same geographic location (Table 1). This implies that longer than 8-year rotation needs to be prescribed when higher heartwood content is desired to enhance the natural durability and decorative value of teak wood products.

Heartwood percentage showed a significant positive correlation with ring width and BH diameter (Table 2). This indicates that faster growth is associated with higher heartwood content and lower sapwood proportion disproving the general notion that faster grown timber always has higher sapwood content.

Wood Density : Basic wood density varied from 520 to 683 kg/m^3 among the 102 trees sampled with a mean value of 582 kg/m^2 (Table 1). The mean density of 8-year-old is therefore only 5% lower than the average wood density reported for 51-52-year-old trees grown in the same geographic location (Bhat *et al.*, 1985; 1989). However, this is comparable with the wood density of suppressed trees of age 51-52 years (Bhat *et al.*, 1987) and 6% greater than the density of 27-year-old teak grown in Nigeria (Sanwo, 1987). Apparently, juvenile wood in teak is not always inferior to mature wood in properties like density and strength as shown by Sanwo (1987).

Analysis of Variance (ANOVA) shows that wood density did not differ significantly either between the two populations (protected vs unprotected plantations from insect defoliation) or between the plots (Table 3). The relatively low value of coefficient of variation (Table 1) indicates that tree-to-tree differences are small with low phenotypic variation. The influence of environmental factors like locality on wood density is reported to be greater than the seed source of 36-year-old teak (Purkayastha *et al.*, 1973; Purkayastha and Sathyamurthy 1975). This may be one reason why Nigeria-grown teak showed comparatively low density. Density is also not related either to BH diameter, ring width or heartwood percentage (Table 3).

Conclusions and Recommendations

1. There is no large difference in the wood density between 8-year-old and mature (older) teak trees.

2. As the heartwood percentage is lower than half the value of 51-52-year-old trees, longer than 8-year-rotation may be necessary when higher heartwood content

Table 3

F values of ANOVA for 8-year-old teak

Source of variation	d.f.	Density	BH diameter	Heart-wood (%)
Populations (Protected *vs* unprotected from insect defoliation)	1	1.024^{ns}	0.183^{ns}	0.092^{ns}
Plots	3	0.996^{ns}	0.727^{ns}	0.128^{ns}
Residual	3	167.125		
Total	7			

is desired for the renowned natural durability and decorative value of the teak wood products. However, lower heartwood content is desirable for pulping and preservative treatment of thinning material for longer durability.

3. Faster growth in plantation-grown teak in Nilambur at age 8-years does not affect wood density but increases heartwood percentage considerably. A word of caution is however necessary, as the relationship between growth rate and wood properties seems to be complex and often specific to heredity and growing conditions, including silvicultural techniques.

Acknowledgements

The author is thankful to Dr. S. Chand Basha, Director, KFRI for his constant encouragement and approval of this paper for publication. The collection of wood samples from the experimental teak plantations of insect defoliation study by Drs. K.S.S. Nair and V.V. Sudheendra Kumar, Entomology Division, KFRI, was gratefully acknowledged. Thanks are due to Mr. P.K. Thulasidas for rendering technical help.

SUMMARY

Three wood properties, viz. ring width, basic density and heartwood percentage were studied in breast height in 102 trees sampled from four plots of 8-year-old teak (*Tectona grandis* L.f.) plantation in Nilambur (Kerala). Heartwood proportion by volume was only 30%, which is lower than half the value recorded for 51-52-year-old trees grown in the same geographic location. Mean basic density (582 kg/m^3) was only about 5% lower than the average density reported for 51-52-year-old trees grown in the same location. On the other hand, the density value is about 6% greater than the recorded for 27-year-old teak grown in Nigeria. Faster growth was associated with higher heartwood percentage while wood density was independent of growth rate.

आठ वर्षीय सागौन के सारकाष्ठ समानुपात और काष्ठ घनत्व पर एक टिप्पणी

के०एम० भट्ट

सारांश

तीन काष्ठ गुणों अर्थात् वलय की चौड़ाई, आधारभूत घनत्व और सारकाष्ठ समानुपात का अध्ययन नीलाम्बूर (केरल) रोपवनों के 8 वर्षीय सागौन *(टैक्टोना ग्रांडिस* लि० वत्स) के चार भूखण्डों से नमूना निकाले 102 वर्षों की वृक्ष ऊँचाई पर किया गया। आयतन से सारकाष्ठ का समानुपात केवल 30% था जो अधिक पुराने 51-52 वर्षीय वृक्षों से, जिन्हें उनके समान भौगोलिक दशाओं में उगाया जा रहा था, समानुपात में आधे से कम है । माध्य आधारभूत घनत्व (582 किग्रा/घन मीटर) उसी स्थान में उग रहे 51-52 वर्षीय वृक्षों के लिए सूचित की गई औसत आधारभूत घनता से केवल लगभग 5% कम है । इसके विपरीत, नाइजीरिया में उगाए जा रहे सागौन के 27 वर्षीय वृक्षों के लिए आलेखित घनता से ये लगभग 6% अधिक है । अधिक वृद्धि को सारकाष्ठ के अधिक प्रतिशत से जोड़ा गया है जबकि काष्ठ घनत्व को बढ़ने की गति से स्वतन्त्र पाया गया है ।

References

Bhat, K.M., K.V. Bhat and T.K. Dhamodaran (1985). Wood and bark properties of branches of selected trees species growing in Kerala. *KFRI Res. Rep.* **29.** Peechi 34 p.

....(1987). A note on specific gravity differences between dominant and suppressed trees in teak. *Indian J. For.* **10** : 61-62.

....(1989). Radial patterns of density variations in eleven tropical Indian hardwoods. *Holzforshung* **43** : 45-48.

Ferguson Jr., I.H.A. (1934). Thickness of heartwood and sapwood of teak *(Tectona grandis* L.f.) *Tectona* **27** : 313-327.

Nair, K.S.S., V.V. Sudheendra Kumar, R.V. Varma and K.C. Chacko (1985). Studies on the seasonal incidence of defoliators and the effect of defoliation on volume increment of teak. *KFRI Res. Rep.* **30** : Peechi 78 p.

Purkayastha, S.K. and K.R. Sathyamurthy (1975). Relative importance of locality and seed origin in determining wood quality in teak. *Indian Forester,* **101:** 606-607.

Purkayastha, S.K., R.D. Tandon and K.R. Rao (1973). A note on the variation in wood density in 36-year old teak trees from different seed origins. *Indian Forester* **99** (4) : 215-217.

Sanwo, S.K. (1987). The Characteristics of sown-formed and stem-formed wood in plantation grown teak (*Tectona grandis* L.f.) in Nigeria. *J. Inst. Wood Sci.* **11** : 85-88.

EFFECT OF VESICULAR ARBUSCULAR MYCORRHIZAE ON THE GROWTH AND MINERAL NUTRITION OF TEAK (*TECTONA GRANDIS* LINN. F.)

V.V.K. DURGA* AND SANJAY GUPTA**

Introduction

It is a well established fact that root colonization by Vesicular-Arbuscular Mycorrhizal fungi helps in host plant growth and nutrition (Mosse, 1973; Menge *et al.*, 1982; Phillips and Hayman, 1983). Here, an attempt is made to study the effect of VAM fungi on the growth of a commercially important tree, *T. grandis* Linn.f. belonging to family Verbenaceae, in its early stages of establishment. The mineral nutrition of the host plant as influenced by the Mycorrhizal fungi in addition to growth parameters were studied in polybags so as to be in a better position to predict responses in field.

The "dilution-concentration method" (Jarrel and Beverly, 1981), is a useful method in screening of VAM fungi for beneficial nutritional host plant responses. Dilution in concentrations could be due to increased dry matter production, while increased concentrations are due to more accumulation of nutrients or due to a loss of plant dry matter. A set of three symbols - total element accumulation, yield (given by the product of respective fresh weight and concentration) and mineral nutrient concentration were recorded for all the treatments. A series of eleven such potential growth responses were earlier recorded by Jarrel and Beverly.

The growth parameters studied here in relation to plant growth were, girth of the plant, number of leaves, root length of the plant, total fresh weight and total dry weight of the plant, dry weight of shoot/total dry weight of the plant, in all the treatments as evidenced after a period of four months, after subjecting to various treatments.

Materials and Methods

Six month old, healthy, disease-free Teak stumps were obtained from Social Forestry Division, Warangal and were transported in a physiologically good condition to Forest Research Centre, Mulugu (Medak District), A.P. They were planted in polythene bags (4.95 kg soil capacity), containing sterilized soil, which had a composition of red soil: black soil: sand in the ratio 5 : 3 : 2. The soil pH, electrical conductivity and concentrations of various macro and micro nutrients were analysed. The absence of fungi in the soil is well established by culturing the soils on PDA (Potato-Dextrose-Agar) medium. The

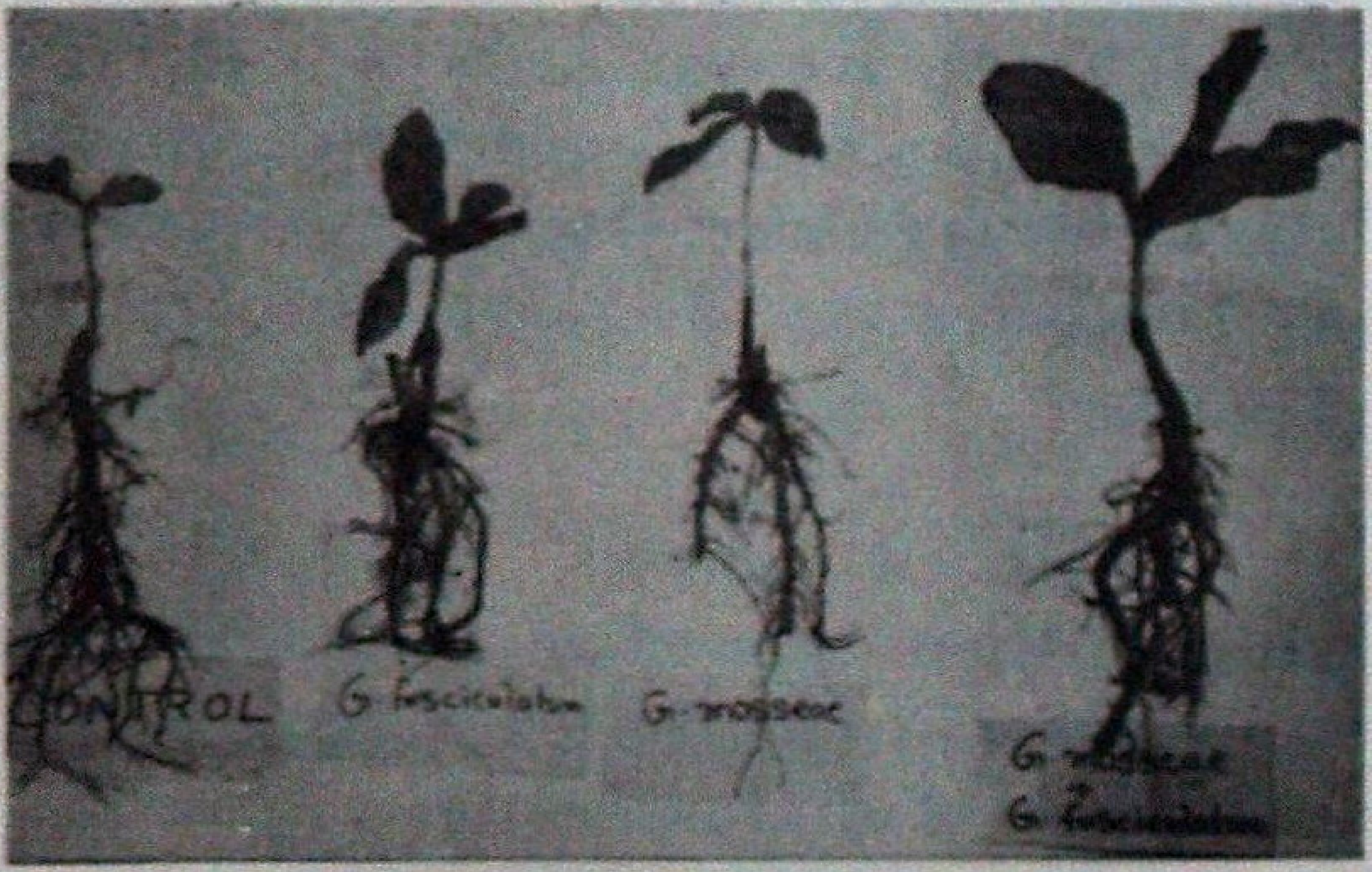
---

* Research Scholar

** State Silviculturist, Hyderabad (Andhra Pradesh)

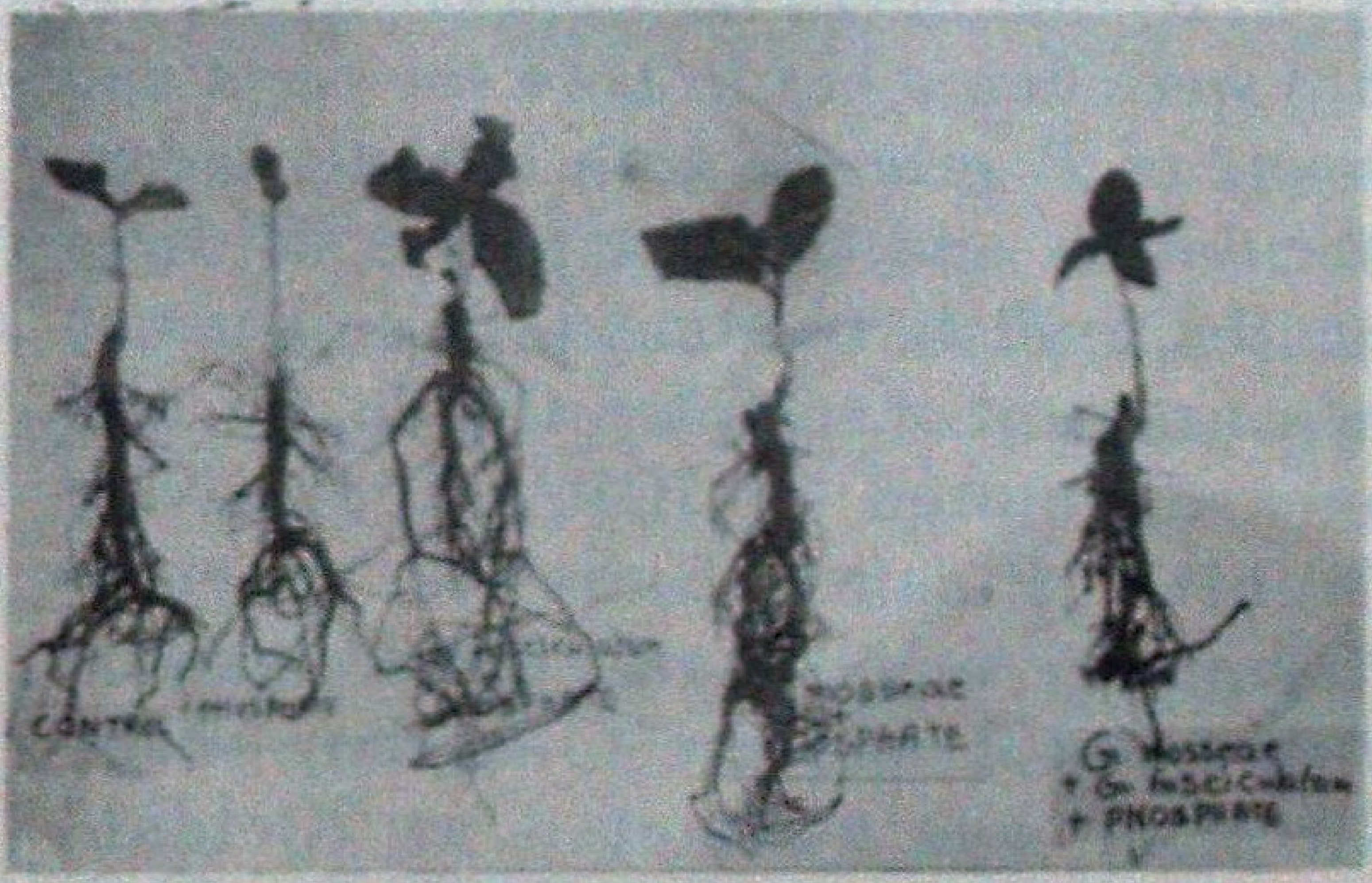
Fig. 1

Fig. 2



CONTROL
G. fasciculatum
G. mosseae
G. mosseae
G. fasciculatum

Fig. 3



CONTROL
mosseae
PHOSPHATE
G. mosseae
+ G. fasciculatum
+ PHOSPHATE

VAM experiments on *Tectona grandis* at Mulugu

stumps were allowed to grow for a period of 3 months, so as to develop leaves and lateral root growth. Colonization experiments (Phillips and Hayman, 1973) revealed an absence of infection by VAM in Teak plants raised from stumps.

Glomus mosseae and *G. fasciculatum* raised as pure cultures on a genetically pure variety of *Cenchrus ciliaris* var. Molopo in sterilizd soil which had the some composition as given above. The selection of these strains followed the screening of forest soils supporting *T. grandis*. 3.5 kg of inoculum having 80-100 spores/100 gm of soil was thoroughly mixed with 1.45 kg of sterilized soil and filled in polybags of 4.95

kg soil capacity. The Teak plants were then transplanted to these bags.

The treatments consisted of addition of the two VAM fungi *G. mosseae* and *G. fasciculatum* separately and in combination with each other, to the three month old teak plants raised from stumps. In addition, the effects of phosphorus alone, and in combination with all the VAM fungal treatments were also studied (Fig. 1). Low concentrations of phosphorus that is, 100 mg (having 52% PO_4 by mass) of rock phosphate, per polybag were added. The non inoculated plant, with no addition of VAM fungi, and phosphorus served as control. The plants were well watered and all the plants were supplied once with modified Hoagland's solution (minus phosphate), two months after inoculation.

The concentration of macro-nutrients (N, P, K) and micro-nutrients (Cu, Zn, Fe, Mn) were found out in both the roots and shoots of *T. grandis* both initially before inoculation and after a period of three months, in all the treatments by destructive measurement of samples. Cu, Zn, Fe, Mn, were estimated by ICPA (Inductively Coupled Plasma Emission Spectro Photometry Analysis) after initial digestion with tri-acid mixture (Jackson, 1958). Nitrogen was estimated as Kjeldahl Nitrogen and K was estimated on a flame photometer after initial digestion with tri-acid mixture. Ca^{++} in the plant exudates was estimated by titrating them against 0.02 M EDTA, using Muroxide indicator.

Results

The various physical and chemical parameters of the experimental soil are indicated in Table 1. The phosphate content of the soil is quite high, while the soil pH(7.0) is in the same range, as is generally seen in *T. grandis* rhizosphere soils.

It is seen from Table 2 that *G. mosseae + G. fasciculatum* shows greater increase in girth, number of leaves, total fresh weight, total dry weight and total fresh weight/total length of the plant while there is a decrease in root length and dry weight of shoot/total dry weight of the plant. These changes are also consistent to a great extent in *G. fasciculatum* + Phosphate, followed by *G. mosseae* + Phosphate and *G. fasciculatum* while *G. mosseae + G. fasciculatum* + Phosphate shows a decrease in many growth parameters.

Table 3 shows an increase in the concentrations of all nutrients with the exceptions of N and Fe in all treatments including control, when compared with initial concentrations. In *G. mosseae + G. fasciculatum* and G. fasciculatum + Phosphate treatments N, K, Zn concentrations decreased in both roots and shoots, while P concentration increased and Fe concentration decreased in only the shoots.

Table 4 shows the mineral accumulation (respective fresh weight x respective nutrient concentration) in roots and shoots of all treatments.

Table 5 shows the graphical representation in the three parameters - change in nutrient accumulation, change in yield and change in concentration, as effected by the imposed treatments, in the roots and shoots of all plants.

Table 6 shows a general increase in pH, and a decrease in electrical conductivity and Ca concentrations of *G. mosseae + G. fasciculatum* + Phosphate and *G.*

Table 1

Physcial and chemical parameters of the experimental soil

pH	E.C (in mmhos/cm)	Fe (mg/gm)	Cu (mg/gm)	Zn (mg/gm)	Mn (mg/gm)	P (mg/gm)	K (mg/gm)	N (mg/gm)
7.8	0.395	0.978	0.36	0.451	3.629	9.009	11.219	7.3

Table 2

Growth parameters in T. grandis after a period of four months

	Girth* (cm)	No.of* leaves plant)	Fresh wt* of Root (gm/ plant)	Fresh wt* of Shoot (gm/ plant)	Total* fresh wt. (gm/ plant)	Root* length (cm)	Total* fresh wt. /total length of plant (gm/cm/ plant)	Fresh wt* of Root/ Root length (gm/cm/ plant)	Total* dry wt. (gm/ plant)
Control	1.33	7.00	6.63	0.77	7.39	20.00	0.25	0.33	5.94
G. mosseae	1.50	2.67	8.70	1.05	7.42	27.00	0.18	0.32	13.42
G. fasciculatum	1.83	3.67	7.17	0.80	7.36	22.67	0.27	0.32	6.43
G. mosseae + *G. fasciculatum*	2.00	17.67	7.31	1.41	8.72	21.33	0.31	0.342	13.20
Phosphate	1.00	3.33	8.48	1.09	9.57	24.83	0.29	0.341	8.57
G. mosseae + Phosphate	1.50	4.00	4.80	0.76	5.77	23.33	0.18	0.21	6.92
G. fasciculatum + Phosphate	2.50	6.67	8.02	1.12	9.14	22.33	0.32	0.36	11.87
G. mosseae + *G. fasciculatum* + Phosphate	1.67	15.67	4.89	0.93	5.78	20.33	0.20	0.24	5.89

* Readings are average of three values

fasciculatum as estimated from total plant exudates.

Discussion

Significant increases in dry matter are seen in *G. mosseae* + *G. fasciculatum* + Phosphate treatments (Table 2). Such increases were also found earlier (Antunes and Cardoso, 1991; Eivazi and Weir, 1989). Increases in total fresh weight and total fresh weight/total length of plant are also consistently higher (Table 2). In contrast, root length decreased in *G. mosseae* + *G. fasciculatum* + Phosphate treatments, showing that the phosphate availability effects root geometry.

Uptake of P is observed in *G. mosseae* + *G. fasciculatum* and *G. fasciculatum* + phosphate shoots (Table 3 and 4). Such an uptake of P was also recorded earlier

Table 3

Mineral nutrient concentration in T. grandis treatments after a period of three months

Caculated per plant

Treatment	Fe (mg/gm)	Cu (mg/gm)	Mn (mg/gm)	Zn (mg/gm)	P (mg/gm)	K (mg/gm)	N (mg/gm)
Initial (S)	1.2690	0.0081	0.06299	0.02860	1.9148	6.4480	4.6530
Initial(R)	2.8450	0.0081	0.02866	0.02974	0.0844	1.9240	6.0450
Control (S)	1.1120(↓)	0.0118(↑)	0.13830(↑)	0.04310(↑)	2.6190(↑)	10.5860(↑)	12.8850 (↑)
Control (R)	4.0070(↑)	0.0158(↑)	0.04590(↑)	0.05040(↑)	0.9214(↑)	8.1500(↑)	6.8500(↑)
G. mosseae (S)	1.7920(↑)	0.0132(↑)	0.16240(↑)	0.08500(↑)	2.3840(↑)	9.1560(↑)	9.7580(↑)
G. mosseae (R)	6.7400(↑)	0.0146(↑)	0.05500(↑)	0.12370(↑)	0.9100(↑)	4.9780(↑)	6.1440(↑)
G. fasciculatum (S)	0.7740(↓)	0.0167(↑)	0.13500(↑)	0.04450(↑)	2.2400(↑)	11.9610(↑)	9.4830(↑)
G. fasciculatum (R)	3.8240(↑)	0.0137(↑)	0.04000(↑)	0.07530(↑)	0.7280(↑)	6.8160(↑)	5.0760(↓)
G. mosseae + *G. fasciculatum* (S)	0.6070(↓)	0.0167(↑)	0.13550(↑)	0.05980(↑)	3.2970(↑)	9.6850(↑)	9.1380(↑)
G. mosseae + G. *fasciculatum* (R)	4.9620(↑)	0.1580(↑)	0.04560(↑)	0.06670(↑)	0.8492(↑)	8.0880(↑)	5.3900 (↓)
Phosphate (S)	0.0673(↓)	0.0087(↑)	0.19620(↑)	0.04990(↑)	1.8360(↑)	6.4110(↑)	8.1790(↑)
Phosphate (R)	6.0160(↑)	0.0157(↑)	0.05770(↑)	0.06010(↑)	1.0010(↑)	6.4800(↑)	6.9530(↑)
G. mosseae + Phosphate (S)	0.7920(↓)	0.0111(↑)	0.16010(↑)	0.04720(↑)	4.6270(↑)	9.7560(↑)	11.4880(↑)
G. mosseae + Phosphate (R)	6.8620(↑)	0.2150(↑)	0.08840(↑)	0.07630(↑)	0.9654(↑)	6.7720(↑)	7.7250(↑)
G. fasciculatum + Phosphate (S)	0.7720(↓)	0.0102(↑)	0.12380(↑)	0.04760(↑)	2.8820(↑)	10.2270(↑)	11.2050(↑)
G. fasciculatum + Phosphate (R)	6.3440(↑)	0.0935(↑)	0.04180(↑)	0.08900(↑)	0.5802(↑)	7.2720(↑)	5.2080(↓)
G. mosseae + *G. fasciculatum* + Phosphate(S)	0.3040((↓)	0.0146(↑)	0.09620(↑)	0.06630(↑)	2.3240(↑)	8.6760(↑)	9.5060(↑)
G. mosseae + *G. fasciculatum* + Phosphate(R)	6.6350(↑)	0.0157(↑)	0.09980(↑)	0.16850(↑)	1.1350(↑)	6.8700(↑)	5.8170(↓)

(↑) Denotes an increase in mineral concentration, (↓) Denotes a decrease in mineral concentration.

Table 4

Mineral accumulation and fresh weights of roots and shoots of T. grandis

Treatment	Fe (mg/gm)	Cu (mg/gm)	Zn (mg/gm)	Mn (mg/gm)	P (mg/gm)	K (mg/gm)	N (mg/gm)	Fresh wt. (after 3 months (gm)	Fresh wt.* (after 4 months) (gm)
Control(S)	2.1684	0.0230	0.02690	0.08000	5.1070	20.6400	25.1300	1.9500	-
Control(R)	42.7600	0.1690	0.49000	0.54000	9.8300	86.9600	50.1600	10.6700	6.6300
G. mosseae (S)	3.1180(↑)	0.0229(↓)	0.08000(↑)	0.14790(↑)	4.1480(↓)	15.9300(↓)	16.9790(↓)	1.7400(↓)	-
G. mosseae (R)	62.8842(↑)	0.1360(↓)	0.51400(↑)	1.15400(↑)	8.4900(↓)	45.4900(↓)	39.4600(↓)	9.3300(↓)	8.7000(↑)
G. fasciculatum (S)	1.8344(↓)	0.0396(↑)	0.32000(↑)	0.10600(↑)	5.3100(↑)	28.3500(↑)	22.4750(↓)	2.3700(↑)	-
G. fasciculatum (R)	39.5020(↓)	0.1420(↓)	0.41400(↓)	0.77900(↑)	7.5200(↓)	70.3500(↓)	40.4100(↓)	10.3300(↓)	7.1700 (↑)
G. mosseae + *G. fasciculatum* (S)	1.5050(↓)	0.0280(↑)	0.34000(↑)	0.14800(↑)	8.1800(↑)	24.0290(↑)	22.6600(↓)	2.4800(↑)	-
G. mosseae + *G. fasciculatum* (R)	59.5400(↑)	0.1896(↑)	0.54700(↑)	0.80000(↑)	10.1900(↑)	97.0600(↑)	47.0900(↓)	12.0000(↑)	7.3190 (↑)
Phosphate (S)	2.0900(↓)	0.0270(↑)	0.61000(↑)	0.16000(↑)	5.7100(↑)	19.9400(↓)	25.4400(↑)	3.1140(↑)	-
Phosphate(R)	24.3500(↓)	0.3250(↑)	1.19300(↑)	1.24000(↑)	20.6900(↑)	13.9400(↑)	66.0600(↓)	20.6700(↑)	8.4800 (↑)
G. mosseae + Phosphate (S)	1.5500(↓)	0.0220(↓)	0.31400(↑)	0.09250(↑)	9.0690(↑)	19.1200(↓)	22.5200(↓)	1.9600(↑)	-
G. mosseae + Phosphate (R)	96.0700(↑)	0.3000(↑)	1.23800(↑)	1.06800(↑)	13.5160(↑)	94.8100(↑)	44.5700(↓)	14.0000(↑)	4.8000(↓)
G. fasciculatum + Phosphate(S)	1.6400(↓)	0.0127(↓)	0.21640(↓)	0.10000(↑)	6.1390(↑)	21.7840(↑)	23.8700(↓)	2.1300(↑)	-
G. fasciculatum + Phosphate(R)	77.2100(↑)	1.1380(↑)	0.50900(↑)	1.08300(↑)	7.0600(↓)	88.5000(↑)	47.6000(↓)	12.1700(↑)	8.0200(↑)
G. mosseae + *G. fasciculatum* + Phosphate(S)	1.2160(↓)	0.0580(↑)	0.38500(↑)	0.26500(↑)	9.2960(↑)	34.7000(↑)	38.0200(↑)	4.0000(↑)	-
G. mosseae + *G. fasciculatum* + Phosphate(R)	86.2600(↑)	0.2040(↑)	1.29700(↑)	2.19000(↑)	14.7600(↑)	89.3100(↑)	33.6200(↓)	13.0000(↑)	4.8800 (↓)

(↑) Shows an increase in accumulation of nutrients, (↓) shows a decrease in accumulation of nutrients.

* Nitrogen in Teak roots was estimated in the fourth month.

Table 5

Graphical representation of nutrient accumulation yield and mineral concentration in roots and shoots of T. grandis treatments (Jarrel and Beverly method)

Treatment	Fe	Cu	Zn	Mn	P	K	N
G. mosseae (S)	↑↓↑(C)	↓↓↑(C)	↑↓↑(C)	↑↓↑(C)	↓↓↓(A)	↓↓↓(A)	↓↓↓(A)
G. mosseae (R)	↑↓↑(C)	↓↓↓(A)	↑↓↑(C)	↑↓↑(C)	↓↓↓(A)	↓↓↓(A)	↓↓↓(A)
G. fasciculatum (S)	↓↑↓(D)	↑↑↑(S)	↑↑↓(D)	↑↑↑(S)	↑↑↓(D)	↑↑↑(S)	↓↑↓(D)
G. fasciculatum (R)	↓↓↓(A)	↓↓↓(A)	↓↓↓(A)	↑↓↑(C)	↓↓↓(A)	↓↓↓(A)	↓↓↓(A)
G. mosseae + *G. fasciculatum* (S)	↓↑↓(D)	↑↑↓(D)	↑↑↓(D)	↑↑↑(S)	↑↑↑(S)	↑↑↓(D)	↓↑↓(D)
G. mosseae + *G. fasciculatum* (R)	↑↑↑(S)	↑↑↓(D)	↑↑↓(D)	↑↑↑(S)	↑↑↓(D)	↑↑↓(D)	↓↑↓(D)
Phosphate(S)	↓↑↓(D)	↑↑↓(D)	↑↑↑(S)	↑↑↑(S)	↓↑↓(D)	↓↑↓(D)	↑↑↓(D)
Phosphate (R)	↑↑↑(S)	↑↑↓(D)	↑↑↓(D)	↑↑↑(S)	↑↑↑(S)	↑↑↑(S)	↑↑↑(S)
G. mosseae + Phosphate (S)	↓↑↓(D)	↓↑↑(D)	↑↑↑(S)	↑↑↑(S)	↑↑↑(S)	↑↑↓(D)	↓↑↓(D)
G. mosseae + Phosphate (R)	↑↑↑(S)	↑↑↑(S)	↑↑↑(S)	↑↑↑(S)	↑↑↑(S)	↑↑↓(D)	↓↓↑(C)
G. fasciculatum + Phosphate (S)	↓↑↓(D)	↓↑↓(D)	↑↑↓(D)	↑↑↑(S)	↑↑↑(S)	↑↑↓(D)	↓↑↓(D)
G. fasciculatum + Phosphate (R)	↑↑↑(S)	↑↑↑(S)	↑↑↓(D)	↑↑↑(S)	↓↑↓(D)	↑↑↓(D)	↓↑↓(D)
G. mosseae + *G. fasciculatum* + Phosphate(S)	↓↑↓(D)	↑↑↑(S)	↑↑↓(D)	↑↑↑(S)	↑↑↓(D)	↑↑↓(D)	↑↑↓(D)
G. mosseae + *G. fasciculatum* + Phosphate (R)	↑↑↑(S)	↑↑↑(S)	↑↑↑(S)	↑↑↑(S)	↑↑↑(S)	↑↑↓(D)	↓↓↓(A)

(C) Concentrated (↑↓↑, ↓↓↑)
(S) Synergistic (↑↑↑)
(D) Diluted (↓↑↓, ↑↑↓, ↓↑↑)
(A) Antagonistic (↓↓↓)
* (↓↑↑) A Special case of dilution is seen.

(Eivazi and Weir, 1989). There is and absolute growth depression in *G. mosseae* + *G. fasciculatum* + Phosphate probably due to the high phosphate levels in the rhizosphere. Inhibition of growth due to high P levels is already known.

There is a higher uptake of K as shown by increasing concentration in shoots of *G. mosseae* + *G. fasciculatum* + Phosphate treatments (Table 3 and 4). Such an uptake can be due to mass flow or diffusion depending on soil concentration.

N uptake decreased with phosphate treatments in mycorrhizal plants (Table 4). Such a decrease was also reported earlier (Hamel, *et al.*, 1991). In *G. mosseae* + *G. fasciculatum*, Cu and Zn concentrations were diluted in both roots and shoots (Table 5) and this can be attributed to dry matter dilution effect (Eivazi and Weir, 1989; Hamel *et al.*, 1991). High levels of phosphate are said to depress the rate of Zn uptake (Safaya, 1976; Lambert *et al.*, 1979). Dilution of copper in the shoot tissue concentrations may be due to the inhibition of Zn on Cu (Kausar *et al.*, 1976).

Fe is concentrated in the roots of all the treatments but its transport to shoot system is reduced (Table 3). The mutual inhibitory action of Zn and Fe is well Know (Brar and sekhar, 1976). Increasing concentrations of p and Mn also inhibit Fe translocation (Cumbus *et al.*, 1977), although increased retention in roots in seen.

Mn increased consistently in the shoots and roots of all treatments, and this could be due to its high mobility (Table 4 and 5). The radio-isotope techniques have shown that the rhizosphere may be responsible for solubilization of Mn and Fe (Van Beuchim, 1990).

The interactions between P and other nutrients must be considered if the overall effect on the host plant is to be assessed. Soil P, Mn and Zn are known to have greater predictive values for mycorrhizal dependents (Menge *et al.*, 1982). It is significant that only P and Mn concentrations increased in *G. mosseae* + *G. fasciculatum* and *G. fasciculatum* + Phosphate treatments which also have shown larger growth.

Table 6

pH Electrical conductivity and Calcium contents in the Plant Exudates of T. grandis

Treatment	pH	E.C. (m mhos/cm)	Ca (ppm)
Initial values	7.40	1.250	(Not Estimated)
Control	6.75	1.380	256
G. mosseae	6.65	1.410	352
G. fasciculatum	7.80	1.110	184
G. mosseae + *G. fasciculatum*	7.45	1.310	152
Phosphate	7.85	1.240	264
G. mosseae + Phosphate	7.45	1.340	336
G. fasciculatum + Phosphate	7.85	1.240	264
G. mosseae + *G. fasciculatum* + Phosphate	7.10	1.240	368

The cation Ca^{++}, given out in plant exudates in less in *G. mosseae* + *G. fasciculatum* and *G. fasciculatum* + Phosphate treatments (Table 6). It is a secondary constituent of poly phosphate granules and can stimulate alkaline phosphate activity. Generally lower concentration of Ca are found in mycorrhizal plants (Jarrel and Beverly, 1981). The pH and electrical conductivity of the plant exudates on the other hand, increased in the following order : *G. mosseae* + *G. fascicuilatum* > *G. fasciculatum* + Phosphate > *G. mosseae* + Phosphate > *G. fasciculatum* (Table 6).

Conclusion

Higher growth and accumulation of phosphorus is seen in *G. mosseae* + *G. fasciculatum* and *G. fasciculatum* + Phosphate treatments followed by *G. fasciculatum*. Mn concentration also increased in these treatments, while N, K, Cu and Fe concentrations decreased or diluted. It is possible that Mn is transported along with poly phosphate granules.

Different mycorrhizal fungi respond differently to host species and these differences reflect selection pressures which favour certain host-fungus combinations (Smith *et al.*, 1972). The variation between genotypes can be used in selection of varieties, whose infection is rapid and nutrient uptake is increased from nutrient deficient systems (Smith *et al.*, 1972).

A combination of *G. mosseae* + *G. fasciculutum* inoculation can be the best treatment while inoculation of *G. fasciculatum* with low P concentration can also give good results. Excess phosphate in the rhizosphere can hamper the growth of the plant by mere accumulation in the root of the plant as seen in *G. mosseae* + *G. fasciculatum* + Phosphate treatments. The better growth of *G. fasciculatum* treated plants over that of *G. mosseae* treated plants proves that there is a certain degree of specificity in host-fungus interactions. The higher phoshate content in the soils could have effected the specific interactions between the host and fungi.

SUMMARY

The effect of VAM Fungi (*Glomus fasciculatum* and *Glomus mosseae*) on initial establishment and mineral nurition of Teak was studied. The uptake of various macro-nutrients, (N,P, K) and micro-nutrients (Cu, Zn, Fe, Mn) studied along with various growth parameters. *G. mosseae + G. fasciculatum* treated plants which registered greater growth, also showed an increase in the concentrations of Phosphate, K and Mn, while N, Cu, Zn, Fe concentrations decreased in the shoots. The plants to which *G. fasciculatum* in combination with a small amount of rock phosphate was given was the next best treatment followed by *G. fascicualatum* alone treated plants. *G. mosseae + G. fasciculatum* + Phosphate treatment proved to be deleterious to the growth of the teak plants. The possible role of VAM on the growth of Teak is discussed keeping in view the specificity of host-symbiont relationship.

सागौन (*टैक्टोना ग्रांडिस लि० वत्स*) की वृद्धि और खनिज पोषण पर आशयक - आर्बुस्कुलर कवकमूलों का प्रभाव

वी०वी०के० दुर्गा व संजय गुप्त

सारांश

सागौन की आरम्भिक स्थापना और खनिज पोषण पर वैम कवकों (*ग्लोमस फैस्सीकुलेटम* और *ग्लोमस मोसी*) के प्रभाव का अध्ययन किया गया । बड़े पोष्याहारों (नाइट्रोजन, फास्फोरस और पाटोशियम) और छोटे पोष्याहारों (तांबा, जस्ता,

लोहा और लोहक) के उद्ग्रहण का अध्ययन कई वृद्धि परिमापों पर किया गया । *ग्लो० मोसी* + *ग्लो० फैस्सीकुलेटम* से उपचारित पौधों में जिनकी वृद्धि तेज रही, उनमें फास्फेट, पोटाशियम और लोहक का जमाव भी अधिक रहा किन्तु उसके प्ररोहों में नाइट्रोजन, तांबा, जस्ता और लोहे का जमाव घटा । जिन पौधों का *ग्लो० फैस्सीकुलेटम* से उपचार थोड़ा सा चट्टानी फास्फेट मिलाकर किया गया वह सबसे अच्छा रहा उसके बाद केवल *ग्लो० फैस्सीकुलेटम* से उपचारित पौधे रहे । *ग्लो० मोसी* + *ग्लो० फैस्सीकुलेटम* + फास्फेट उपचार सागौन पौधों के लिए हानिकर रहा । पोषित-सहजीविता संबन्ध की विशिष्टता को ध्यान में रखते हुए सागौन की वृद्धि पर वैम कवकों की संभावित भूमिका पर विचार किया गया है ।

References

Antunes, V. and E.J.B.N. Cardoso (1991). Growth and nutrient status of Citrus plants as influenced by mycorrhiza and phosphorous application, *Plant and Soil* **31** : 11.

Brar, M.S. and G.S. Sekhar (1976). Effect of copper on Zinc absorption by wheat seedlings and its translocation with in the plants, *Plant and Soil*, **45** : 137.

Cumbus I.P., D.J. Hornsey and L.W. Robinson (1977). The influence of P, Zn, and Mn on absorption and translocation of Fe in water cress, *Plant and Soil*, **48** : 651.

Eivazi, F., and C.C. Weir (1989). Phosphorous sand Mycorrhizal interaction on uptake of phosphorus and trace elements by maize, *Fert. Res.* **21** (1) : 19.

Hamel Chantal, Valentin Furlan and Donald, L. Smith (1991). N_2 fixation and transfer in a field grown mycorrhizal corn and soybean crop, **133** : 117.

Jackson, M.L. (1958). *Soil chemical Analysis*, Prentice Hall International Inc., Englewood Cliffs, New Jersey.

Jarrel, W.M., and R.B. Beverly (1981). The dilution effect in the plant mutrition studies, *Advances in Agronomy*, **34 :** 197.

Kausar, M.A., F.M. Chaudhry, A. Rashid, A. Latif and S.M. Alam (1976). Micro-nutrient availability to cereals from calcareous soil : I. Comparative Zn and wheat, Plant and Soil (1979) **45** : 397.

Lambert, D.H., D.E. Baker and H. Cole, Jr (1979). The role of mycorrhizae in the interaction of P with Zn and Cu and other elements. *Soil. Sci. Am. Jour*, **43** : 976.

Menge, J.A., W.M. Jarrell, C.K. Labanauskas, J.C. Ojula, C. Haszar, E.L.V. Johnson and D. Sibert (1982). Predicting mycorrhizal dependency of Troyer citrange on *G. fasciculatum* is california Citrus Soils and Nurserymixes, *Soil. Sci. Soc of Am. Jour.* **46** : 62.

Mosse, B. (1973). Advances in the study of Vesicular Arbuscular Mycorrhiza, *Annual Review of Phytopathology*. **11** : 171.

Phillips, J.M. and D.S Hayman (1973). Improved procedures for cleaning roots and staining parasite and VAM fungi for rapid assessment of infection, *Trans. Br. Mycol. Soc.*, **55** : 283.

Safaya, N.M. (1976). Phosphorus-Zn interaction in relation to absorption rates of P, Zn, Cu, Mn, Fe in corn, *Soil Sci. Soc. Am. Jour.* 40 : 719.

Smith, S.E., A.D. Robson and L.K. Abbott (1972). The involvement of mycorrhizas in assessment of genetically dependent efficiency of nutrient uptake and use. *Plant and Soil* **146** :169.

Van Beuchim, M.L. (1990). *Plant nutrition- physiology and applications*, Klewer Academic Publications.

EVALUATION OF SOME MEDICINAL AND NATURAL PLANT EXTRACTS AGAINST TEAK SKELETONIZER, *EUTECTONA MACHAERALIS* WALK.

P.B. MESHRAM

Forest Entomology Division,
Tropical Forest Research Institute, Jabalpur (Madhya Pradesh)

Introduction

Natural plant products being indigenous resources with insecticidal repellent, antifeedant and growth inhibitor activities are one of the important alternatives to replace synthetic insecticides in the crop pest management programme (Prakash *et al.*, 1989 a). Steets (1975) applied 2.5-10% crude extract of *Azadirachta indica* and *Melia azadirach* against Mexican bean beetle inhibited 100% larvae mortality occurred. 5 and 10% aqueous solution of neem leaf extracts inhibited normal development of tobacco cut worms (Somnatsiri and Pathumchartpat, 1979). Ahmed *et al.* (1983) suggested the feasibility of botanical materials for pest control under traditional farming systems. 1 and 5% aqueous extracts of *Annona, Argemone, Calotropis* and *Ricinus* found to be the root forest products against brinjal grub, *H. vigintioctopunctata* (Murlikrishna *et al.*, 1990). Crude leaf extracts of *Andographis paniculata, Azadirachta indica* and *Cymbopogan citratus* showed significant protectant against *L. acuta* (Gupta *et al.*, 1990).

Teak (*Tectona grandis*) is one of the most extensively studied timber species for the damages caused by the insects. Teak skeletonizer *Eutectona machaeralis* causes loss in increment and deformity in the bole of the species. It was reported that a loss in timber of 4.5 m^3 per ha occurs in a year of severe epidemic. Beeson (1941) studied the biology, distribution and economic importance of this insect but as far as control measures are concerned studies and the literature is incomplete. Present study was thus undertaken by evaluating different plant extracts of 32 plant species against teak skeletonizer, *Eutectona machaeralis*. The results of this study are discussed in this paper.

Materials and Methods

Leaves of 32 different medicinal and natural plants were collected from NWFP nursery, Tropical Forest Research Institute, Jabalpur (Table 1). Larvae of *Eutectona machaeralis* were also collected from the foliage of teak and reared in lab by providing fresh leaves of teak as food to the larvae. Food supply was stopped a day prior to the starting of the experiment, so that the starved larvae could be available for releasing to feed on the treated leaves. To find out the efficacy of extracts, tender leaves of teak were collected from field and

Table 1

Effect of crude extracts (5%) against teak skeletonizer, Eutectona machaeralis

Treatments	Av. Leaf area consumed after 24 hrs.			Av. Larval mortality after 24 hrs.	
	(cm^2)	(%)	(Angle)	(%)	(Angle)
Abutilon indicum	1.28	13.33	19.03	13.33	13.70
Acorus calamus	1.60	16.66	21.62	13.33	13.70
Adhatoda vasica	7.86	33.12	27.84	20.00	20.93
Ailanthus excelsa	1.22	12.70	13.51	13.33	13.07
Aloe vera	0.50	5.20	8.41	26.66	26.15
Annona squamosa	0.80	4.16	7.38	26.66	26.15
Aristolachia indica	1.08	5.62	11.89	13.33	13.07
Artemisia maritina	1.64	8.53	14.03	13.33	13.07
Azadirachta indica	0.22	1.14	2.76	46.66	43.07
Bursera penicillata	1.54	8.02	10.62	00.00	00.00
Calotropis procera	0.00	0.00	00.00	60.00	53.77
Chrysanthemum indicum	1.54	8.00	13.25	6.66	6.85
Clerodendrum indicum	1.04	5.41	8.05	33.33	30.00
Datura metel	0.14	0.72	2.18	53.33	49.93
Eucalyptus hybrid	3.46	18.01	19.68	20.00	19.93
Ficus benghalensis	1.68	8.74	10.65	6.66	6.85
Jatropha curcas	3.50	18.22	24.80	13.33	13.07
J. gossypifolia	3.00	15.62	20.40	13.33	13.07
Lantana camara	1.30	2.27	5.39	13.33	13.70
Tagetes spp.	3.04	15.83	18.35	40.00	36.85
Melia azedarach	2.10	10.93	17.20	6.66	6.85
Nerium odorum	2.32	12.08	18.11	20.00	20.93
Ocimum sanctum	7.26	37.81	37.62	13.33	13.07
Operculina turethum	2.16	12.24	17.38	13.33	13.70
Parthenium hysterophores	2.52	13.12	16.20	13.33	13.70
Plumbago rosea	4.08	21.24	26.96	6.66	6.85
Pongamia pinnata	2.66	13.85	17.23	0.00	0.00
Ricinus communis	4.08	21.24	23.65	6.66	6.85
Polyathea longifolia	1.74	9,06	13.48	13.33	13.07
Tabernaemotana divaricata	1.76	9,16	11.39	20.00	19.93
Tribulus terrestris	3:58	18.64	20.27	13.33	13.70
Vitex negundo	2.98	15.51	18.27	6.66	6.85
Control (untreated)	10.88	39.07	48.81	0.00	0.00
SEM +		10.52		17.40	
CD at 5%		20.61		34.09	

then washed with tap water before cutting, into circles of about 5 cm diameter. The plant extracts in concentration of 5 per cent were prepared and sprayed uniformly on numbered circled cut leaves by a hand automizer @1 ml emulsion per circled leaf. Each sprayed circled leaf was then dried in air.

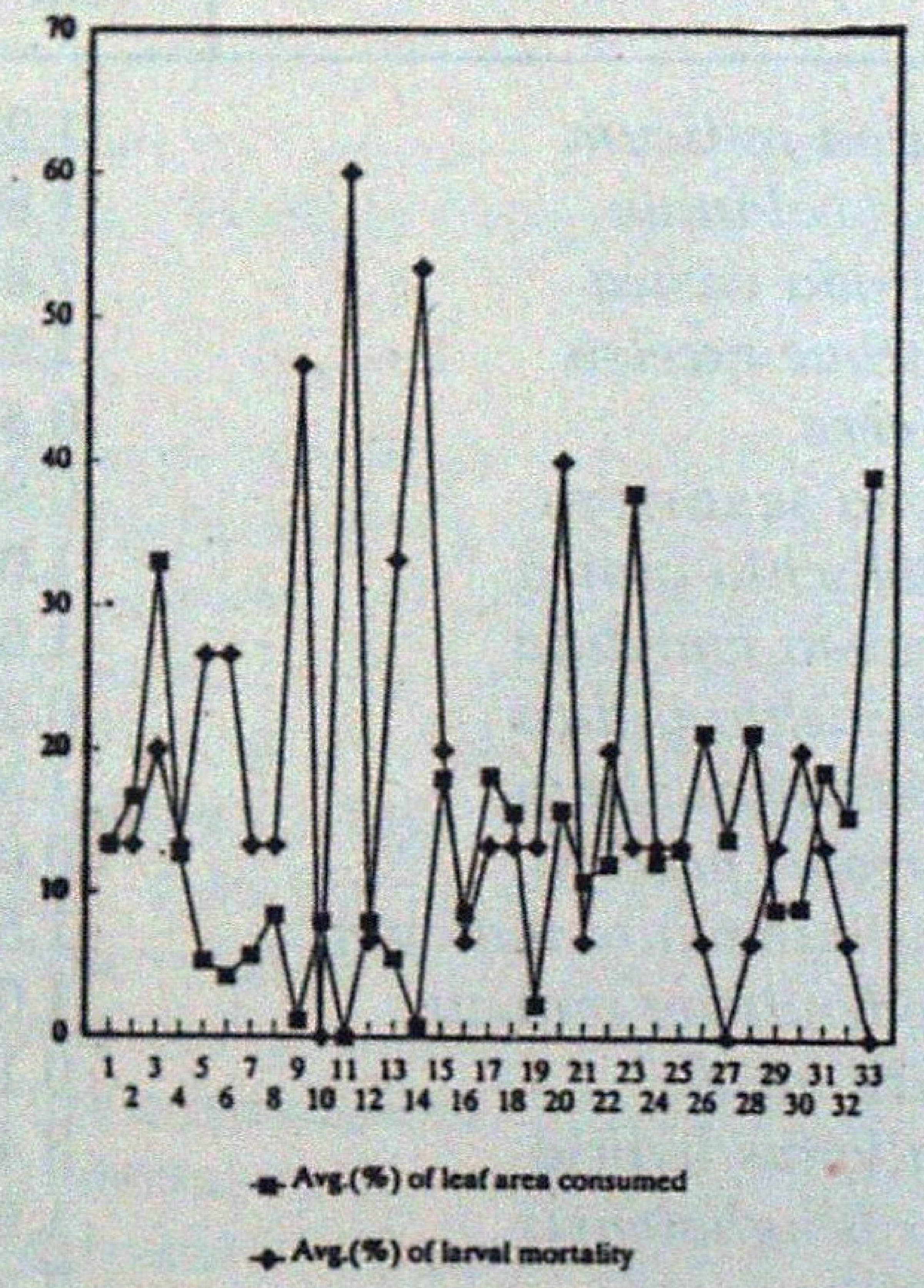
For studying the antifeedant property, a pair of starved third instar larvae of equal size were released on each circled sprayed leaf. The leaf was then covered by a petridish. After 24 hrs of releasing the larvae on treated leaf, the percentage of leaf area consumed by the larvae was calculated by using the leaf area meter (Systronics).

To study the insecticidal effect, five starved third instar larvae were released on the treated leaves in each replication. After 24 hrs of releasing the larvae on treated leaves, the per cent mortality was recorded. Both the trials, were conducted in five replications of each treatment, the control being maintained without treatment. The percentage of leaf area consumed and the larval mortality value were converted to angle value. The data was then analysed statistically for evaluating the efficacy of the extracts.

Results and Discussion

Antifeedant effect : The data based on the percentage of leaf area consumed showed that out of 33 treatments (Table 1 and Fig. 1), 5% fresh leaf crude extract of *Calotropis procera* proved to be most effective in minimising the consumption of leaf as compared to control. Data showed that the leaf consumed by larvae was almost nil as compared to 39.07 per cent in control. The treatments *Datura metel* and *Azadirachta indica* under which the leaf consumption were 0.72, 1.14 per cent. It is therefore, concluded that *C. procera, Datura metel* and *Azadirachta indica* are effective in the decreasing order to control the damage due to larvae of *E. machaeralis* on teak.

Fig. 1



Effect of crude extracts against teak skeletonizer *E. machaeralis*

Insecticidal effect : Insecticidal test records on the number of larvae killed in each treatment were noted after 24 hrs. and summarised in Table 1 and Fig. 1. The highest mortality of larvae was recorded under the influence of 5% fresh leaf crude extracts of *Calotropis procera* 60.00 per cent, *Datura metel,* 53.33 per cent as against nil mortality in control. *Azadirachta indica* and Marigold (*Tagetes* spp) were also effective as evidenced by 46.66 and 40.00 per cent mortality respectively. The per cent mortality of *E. machaeralis* larvae after 24 hrs of treatment including control range between 0 to 60 per cent. The least mortality (6.66 per cent) was recorded in

Chrysanthemum indicum, Ficus benghalensis, Melia azedarach, Plumbago rosea, Ricinus communis and *Vitex negundo. Pongamia pinnata* leaf extract proved totally ineffective.

Thus it can be concluded that the fresh leaf extracts of *Calotropis procera, Datura metel* and *Azadirachta indica* were found to be most effective against teak skeletonizer, *Eutectona machaeralis*. The results of the present investigations are of immense importance in the insect pest control, considering its harmless and pollution free implications on the environment further avoiding the operational and residual hazards that involve in the use of organic and inorganic insecticides. Field trials and studies are in progress to isolate the active compound responsible for the antifeedant and insecticidal effect against this pest.

Acknowledgements

The authors are thankful to Dr. B.N. Gupta, Director and Shri R.B. Lal, Group Co-ordinator Research, Tropical Forest Research Institute, Jabalpur for encouragements and providing necessary facilities.

SUMMARY

Crude extract (5%) of fresh leaves of 32 different medicinal and natural plants were tested under laboratory against third instar larvae of teak skeletonizer, *Eutectona machaeralis* to evaluate their antifeedant and insecticidal effect. This investigation has revealed that the extracts of *Calotropis procera* followed by *Datura metel* and *Azadirachta indica* was found to be most effective and potent antifeedant against this pest.

सागौन पर्णकंकालक, *युटैक्टोना मेकेरेलिस* वाक० के विरूद्ध कतिपय औषधीय व प्राकृतिक निस्सारों का मूल्यांकन

पी०बी० मेश्राम

सारांश

32 विभिन्न औषधीय व प्राकृतिक पादपों की ताजा पत्तियों का कच्चा निस्सार (5%) सागौन पर्णकंकालक, *युटैकटोना मेकेरेलिस* के तृतीय रूप जातक के विरुद्ध पोषण विरोधी और कीटनाशी प्रभाव जानने के लिए प्रयोगशाला में परीक्षित किया गया । इस अन्वेषण से पता लगा कि इस नाशिकीट के विरूद्ध पोषण विरोधी के रूप में *कैलोट्रोपिस प्रोसेरा* का निस्सार, उसके बाद प्रभाव क्रम में *धतुरा धातु* और *अजेडिरेक्टा इंडिका* निस्सार प्रभावकारी रहे ।

References

Ahmed, S., M. Grainge, J.W. Hylin, W.C. Mitchel and J.A. Litsinger (1983). Investigating the feasibility of using botanical materials for pest control under traditional farming systems : a suggested approach *Proc. 2nd Int. Neem Conf.* Raurschtolzhausen, Federal Republic of Germany 25-28 May, pp. 545-550.

Beeson, C.F.C. (1941). *The ecology and control of forest insects of India and neighbouring countries.* Vasant Press, Dehradun pp. 1002.

Gupta, S.P., A. Prakash and Jagadishwari Rao (1990). Biopesticidal activity of certain plant products against rice earhead bug, *Leptocorisa acuta* Thumb. *J. Appl. Zoo. Res.* **1** (2) : 55-58.

Muralikrishna, Rao S., K.C. Chitra, D. Gunesekhar and P. Rameshwar Rao (1990). Antifeedant properties of certain plant extracts against second stage larva of *Henosepilachna vigintioctopunctata* Fab. *Ind. J. Ent.* **52** (4) : 681-685.

Prakash, A., S.N. Tewari and Jagadishwari Rao (1989 a). Exploitation of national plant products against pests and diseases in rice ecosystems. *Proc. National Dev. and Natural Resources Conv.* at Muzaffarnagar (U.P.) on 8-10 Oct., pp. 23-26.

Somnatsiri, K. and W. Pathumchartpat (1979). Some attempts to develop new insecticides from plant sources. Food and Fertilizer Technology Center, Taipei, Taiwan, (FFTC) *Book Series,* **14** : 158-165.

Steets, R. (1975). Effects of crude extracts on the Meliaceae *Azadirachta indica* and *Melia azedirach* on various insect pests. *Z. Angew. Ent.* **77** : 306-312.

Snippets PINE

North Carolina State Univ., in cooperation with southern pine producers and secondary users, has formed the Southern Pine Value Added Research Group. The mission of the group is to develop technical information that will accelerate the use of southern pine as a preferred species for mill-work, furniture, and cabinets. Project plans include defining quality needs of secondary users, surveying pine producers to determine their potential for entering the value added market, conducting drying research, and studying machining, fastening, and finishing of southern pine. The research program, directed by group members and housed at the Brandon P. Hodges Wood Products Laboratory at North Carolina State Univ., will be completed within the next 2 to 3 years. Primary and secondary manufacturers, equipment suppliers, trade associations, and grading agencies are encouraged to participate. For further information contact Joseph Denig, North Carolina State Univ., Box 8003, Raleigh, NC -27695-8003 (USA). Fax 919-515-7231.

Source : *Forest Products Journal* Vol. 45, No. 4

ASSOCIATION AND ACTIVITY OF ARBUSCULAR MYCORRHIZAE OF TEAK (*TECTONA GRANDIS*) IN CENTRAL INDIA

R.K. VERMA AND JAMALUDDIN

Forest Pathology Division,
Tropical Forest Research Institute, Jabalpur (Madhya Pradesh).

Introduction

Arbuscular mycorrhizal (AM) fungi belong to lower group of fungi and are widely distributed throughout the world. These fungi are present in all types of soil and form symbiotic association with higher plants. AM fungi are very common in tropical forests while ectomycorrhizae dominates in temperate and coniferous forests. About 95% of tree species of tropical region are reported to be endomycorrhizal. AM fungi infect fine feeder roots and colonize the cortical region from where they extend their mycelia in rhizosphere soil. These mycelia go beyond the depletion zone and help the host plant in nutrient uptake specially phosphorus. Besides this these fungi also protect the host plants from root pathogens and enhance drought resistance (Michelsen and Rosendahal, 1990; Verma and Jamaluddin, 1994).

Teak (*Tectona grandis* L.) is the most important forestry species and extensively grown in Central India. Raman and Gopinathans (1992) studied association and activity of AM fungi in some tropical trees including teak in Tamil Nadu, India. Reena and Bagyaraj (1990) studied growth stimulation of *Tamarindus indica* by selected VAM fungi. Mohankumar and Mahadevan (1987) studied ecological distribution of AM fungi in a tropical forest of Southern India. Thapar and Khan (1973) studied endomycorrhizae of some forest species. The present paper deals with AM colonization of teak at different sites and age, AM mycoflora and effect of AM fungi on growth and biomass production of teak seedlings in nursery.

Materials and Methods

Soil samples along with fine feeder roots were collected from rhizosphere of teak trees and nursery beds. About 500 g soil samples were carried to laboratory from each site. The root bits were sieved out and a portion of it used for assessment of per cent root infection while the rest mixed with 200 g soil of the same sample for multiplication of AM spores. Three replication of the soil samples each of 100 g were made for isolation of AM spores. The spores of AM fungi were isolated by centrifugation and sucrose floatation technique (Walker *et al.*, 1982). AM fungi were multiplied in ploypots containing 1.5 kg sterilized, sand, soil and vermiculite in 1:1:1 ratio under maize cover. The AM spores were also isolated from pots substrate after multiplication (75 days). The spores obtained from natural soil as well as multiplied under maize cover were studied microscopically. The slides were prepared

Table 1

Occurrence and per cent root infection of Arbuscular Mycorhizal fungi of teak at different sites in Madhya Pradesh.

Date of study 1	Locality 2	Nursery/ plantation 3	% root colonization 4	Type of infection 5	AM Species recovered from soil 6
05.10.91	Kanger, Jagdalpur	Plantation	81.5	V/A	*Glomus aggregatum, G. etumicatum, G. macrocarpum Acaulospora scrobiculata, Scbrocystis coremioides*
06.10.91	Geedam, Jagdalpur	Nursery	68.7	V/A	*Glomus aggregatum, G. mosseae, G. etunicatum, Acaulospora scorbiculata, Scultellospora* sp. 1 & 3 *Scbrocystis coremioides*
08.02.94	Seoni	Nursery	65.0	V/A	*Glomus etunicatum, G.mosseae, G. macrocaspum, Acaulospora scrobiculata, Gigaspora* sp. 2.
10.02.94	Rookhad	Nursery	72.0	V/A	*Glomus etunicatum, G. intraradices, G. mosseae, Acaulospora scrobiculata, Scutellospora* sp. 2, *Gigaspora* sp. 1
03.10.94	Jabalpur	Nursery	58.0	V/A	*Glomus intrardices, G. mosseae, G. etunicatum, Gigaspora* sp. 1, *Acaulospora scrobiculata, Scutellospora* sp. 2
08.02.94	Rookhad, Compt, 81 (C 6)	Plantation plus tree	70.0	V	*Glomus etunicatum, G. intraradiaces, G. mosseae, Acaulospora scrobiculata, Scutellospora* sp. 1.
08.02.94	—do— (C 8)	—do—	60.0	V/A	*Glomus etunicatum, G. intraradiaces, G. mosseae, Acaulospora scrobiculata, Scutellospora* sp. 3.
08.02.94	Rookhad, Comot, 205 (PT 48)	—do—	95.0	V/A	*Glomus etunicatum, G. intraradices, G. caledonium, G. mosseae, Acaulospora* sp., *A. scrobiculata, Scutellospora* sp. 2.
08.02.94	—do— (C 5)	—do—	55.0	V/A	*Glomus etunicatum, G. intraradices, G. caleddonium. G. mosseae, Acaulospora* sp., *A. scrobiculata, Scutellospora* sp. 1.

(Contd...)

1	2	3	4	5	6
08.02.94	TSO, Kurai Range (Rookhad (C 19)	TSO	75.0	V/A	*Glomus etunicatum, G. mosseae, G.intraradices, Acaulospora* sp., *Scutellospora* sp. 1 & 2.
08.02.94	—do—	—do—	50.0	V	*Glomus caledonium, G. intraradices, G. mosseae, Acaulospora* sp. *A. scrobiculata, Gigaspora* sp. 2.
08.02.94	—do—	—do—	45.0	V	*Glomus intraradices, G. mosseae, G. etunicatum, Acaulospora* sp. *A. scrobiculata*
10.02.94	Rookhad (IPT, Mysore)	Plantation	65.0	V/A	*Glomus etunicatum, G. intraradices, G. mosseae, Acaulospora* sp. *A. scrobiculata, Gigaspora* sp. 1.
10.02.94	Rookhad (IPT Loas)	Plantation	35.0	V	*Glomus etunicatum, G. aggregatum, G. microcarpum Acaluspora* sp. *Gigaspora* sp. 2.
10.02.94	Rookhad (IPT, Thailand)	Plantation	30.0	V	*Glomus etunicatum , G. mosseae, Acaulospora* sp. *Gigaspora* sp. *G. intraradices, Acaulospora* sp.
10.02.94	Rookhad (IPT, Indonesia)	Plantation	40.0	V/A	*Glomus mosseae, G. etunicatum, Gigaspora* sp. 2, *Scutellospora* sp.1 *Acaulospora* sp.
10.02.94	T.S.O. Beharai (C 19)	TSO	45.0	V	*Glomus etunicatum, G. aggregatum, G.intraradices, G. marcocarpum, Acaulospora* sp. *A. scrobiculata*
10.02.94	Beharai, Seoni	TSO	30.0	V	*Glomus etunicatum, G. intraradices, G. mosseae Acaulospora* sp. *A. scrobiculata, Scutellospora* sp. 3.
10.02.94	Beharai, Seoni	TSO	25.0	V	*Glomus etunicatum, G. celadonium, G. macrocarpum, Acaulospora* sp. *A. scrobiculata, Gigaspora* sp. 2.
10.02.94	Beharai, Seoni	TSO	30.0	V/A	*Glomus etunicatum, G. microcarpum, G. mosseae, Acaulospora* sp., *Scutellospora* sp. 1 & 2.

IPT = International Provenance trial, TSO = Teak seed orchard.

in PVLG and Melzer's reagent + PVLG in 1:1 ratio separately. The spores were identified with the help of published literature and manual (Schenck and Perez, 1990). For study of effect of AM fungi on growth of teak seedlings, the experiment was conducted in sterilized soil + sand in 1:1 ratio in polyethylene bags. Finer roots were removed from root shoot of teak seedling washed with sterile water, and planted in polyethylene bags containing 1.5 kg potting mixture. Ten gramme of AM inoculum was given to each seedling individually. The experimental seedling were kept on polyethylene sheet in groups of 10 in each replication and watered regularly with tube well water. After 7 months the seedlings were uprooted by removing the polyethylene and washing the roots carefully. Height collar diameter, fresh weight were recorded, some fine feeder roots were kept from each replication for assessment of per cent root infection. Dry weight were recorded after oven drying the same at 75⁰C till a constant weight. For assessment of per cent infection, the slides were prepared by method of Phillips and Hayman (1970). One hundred root segments were examined for presence of vesicles and arbuscules. Per cent root infection was assessed by method of Giovannetti and Mosse (1980).

The data was statistically analysed using general linear model ANOVA and a simple correlations between different parameter studied was worked out.

Results

AM fungi recovered from soil samples collected from different sites with per cent root infection, type of infection are presented in Table 1. Maximum root colonization was observed in a plus tree of Rookhad (Compt 205), 95 % followed by Kanger, Jagdalpur (81.5 %) while minimum root colonization was in Teak Seed Orchard (TSO) Beharai, Seoni (25 %). AM fungi isolated from different sites are presented in Table 2 with their frequencies of occurrence.

Table 2

Arbuscular mycorrhizal fungi associated with teak and their frequencies of occurrence at 20 different sites in Madhya Pradesh

AM Species	Frequency
Acaulospora scrobiculata Trappe	17
Acaulospora sp.	06
Gigaspora sp. 1 (Pale-brown)	05
Gigaspora sp. 2 (Pale-hyaline)	03
Glmous aggregatum Schenck & Smith emend Koske	03
G. caledonium (Nicol. & Gerd.) Trappe & Gerd	02
G. etunicatum Becker & Gerd.	19
G. fasciculatum (Thaxter) Gerd. & Trappe emend Walker & Koske	01
G. intraradices Schenck & Smith	13
G. macrocarpum Tulasne & Tulasne	04
G. microcarpum Tulasne & Tulasne	02
G. mosseae (Nicol & Gerd.) Gerd. & Trappe	16
Scutellospora 1 (Pale)	07
Scutellospora 2 (Red)	05
Scutellospora 3 (Whitish)	03
Sclerocystis coremioides Berk. & Broome	02

The data recorded on growth, biomass and per cent root infection of AM treated and control seedlings are presented in Table 3. A simple correlation between these parameters was computed and presented in Table 4.

Table 3

Effect of arbuscular mycorrhizal fungi on growth, biomass and % root infection of teak seedling after 7 months of inoculation

Treatment	Height (cm)	Collar diam.(cm)	Fresh wt. (g)		Dry weight (g)		% root infection
			Shoot	Root	Shoot	Root	
Glomus fasciculatum	13.8	0.54	11.4	17.7	3.5	4.8	33.3
Mixed AM	14.7	0.65	11.8	28.8	4.2	7.5	41.7
Control	13.3	0.51	10.2	14.9	2.3	4.0	20.0
CD at 5 %	NS	NS	NS	NS	1.8	3.4	12.4

NS = Not significant.

Table 4

Simple correlations between different parameters of teak seedlings studied

	Collar (diam.)	Root (FW)	Shoot (FW)	Root (DW)	Shoot (DW)	% root infection
Height	0.24	0.56	0.35	0.59	0.41	0.29
Collar diam.	1.00	0.25	0.17	0.24	0.57	0.20
Root FW	0.25	1.00	0.69	0.99	0.72	0.44
Shoot FW	0.17	0.69	1.00	0.72	0.86	0.03
Root DW	0.24	0.99	0.72	1.00	0.73	0.38
Shoot DW	0.57	0.72	0.86	0.73	1.00	0.12
% infection	0.20	0.44	0.03	0.38	0.12	1.00

FW = Fresh weight, DW = Dry weight.

Discussion

Per cent root colonization, type of infection and AM fungi differs from site to site. It also differs with genetic variability of teak trees. Maximum per cent root colonization (95 %) was recorded in a plus tree (PT 48) at Rookhad Compt. 205, followed by natural forest tree of Kanger, Jagdalpur 81.5% with vesicular arbuscular type of infection. While minimum root infection was found in TSO, Beharai, Seoni trees which ranges between 25-45%. Low infection in TSO is probably due to removal of grasses, weeds and other cultural operations around teak trees which were regularly performed in TSO. All the plus trees of Rookhad forest are heavily infected with AM fungi (55-95%). Per cent root infection in plantation was found to be more than nursery seedlings in Jagdalpur (Table 1). It is clear from the above observations that per cent root colonization depends on site quality as well as genetic variability and age of the plant. The trees with better genome from silvicultural point of view (plus trees) were also found to be better adapted with AM fungi and hence showed more per cent root infection than other normal trees. Raman and Gopinathans (1992) studies association and activity of vesicular arbuscular mycorrhizae of some tropical trees including teak from Southern India and reported maximum root colonization (84 %) in summer followed by late winter (62%) season and minimum colonization in winter (25 %) followed by rainy season (70 %). They also concluded that per cent root colonization depend on soil quality. Some other studies also revealed that low nutrient status of the soil enhance the rate of infection (Hass and Menge, 1990; Boerner, 1990).

On study of root colonization among international provenance trial it was found that provenances from other Asian countries show less root colonization with native AM fungi. For example, provenance from Laos shows 35 %, Thailand 30 % and Indonesia 40 % compared to provenance from Mysore, India 65 % root colonization, which are planted at same site in Rookhad. This observation reveals that the native AM fungi are better adapted to Indian provenance (Mysore) than the provenances introduced from outside the country (Table 1).

Sixteen different species of AM fungi belonging to 5 genera of Glomales were isolated from teak rhizosphere soil sample. Among these *Glomus entunicatum* and *Acaulospora scrobiculeta* are the most widely distributed species followed by *G. mosseae* and *G. intraradices* while *G. fasciculatum* was the rarest species (Table 2). According to Dr. C. Walker, Forestry Commision, Roslin, U.K. *G. etunicatum* is the most widely distributed and *G. fasciculatum* is the rarest species in the world (personal communication). The present findings also confirm his views. Raman and Gopinathans (1992) also reported 14 species of different AM species from Southern tropical forest.

Inoculation of teak seedlings with mixed species of AM fungi significantly enhanced shoot and root dry biomass and per cent root infection (Table 3). Per cent infection is positively correlated with biomass production (Table 4). Use of single species of AM fungi *G. fasciculatum* enhanced height growth (6.2 %), collar diameter (5.8 %), fresh weight (shoot, 12 %; root, 19%), dry weight (shoot, 25 %; root, 20 %) and per cent infection (60%). But these parameters except per cent root infection could not differ significantly with the control, probably due to low root infection of experimental seedlings. Therefore it is concluded that mixed inoculum of AM fungi is more effective to boost the growth and biomass of teak seedling.

SUMMARY

Arbuscular mycorrhizal (AM) fungi of *Tectona grandis* isolated from 20 different sites, including nursery, plantation and natural forests their root colonization and effect of inoculation of AM fungi on growth of teak seedlings were studied. The per cent root colonization ranges between 25-95 at different sites. Genetically superior (plus trees) showed heavy root colonization as compared to other normal trees. Sixteen different AM fungi were isolated and identified belonging to 5 genera of Glomales namely *Acaulospora, Gigaspora, Glomus, Scutellospora* and *Sclerocystis*. Among these *Glomus etunicatum* and *Acaulospora scrobiculata* were found most widely distributed species followed by *Glomus indraradices* and *G. mosseae* while *G. fasciculatum*, was found least frequent. Inoculation of teak seedling with *G. fasciculatum* and mix AM fungi separately showed better height growth, biomass and per cent root infection in nursery compare to uninoculated (control) seedlings. The mix AM inoculum is found more effective to boost the growth and biomass.

मध्य भारत में सागौन (*टैक्टोना ग्रांडिस*) से आर्बुस्कुलर कवक मूलों का संबन्ध और सक्रियता

आर०के० वर्मा व जमालुद्धीन

सारांश

20 विभिन्न स्थानों से, जिनमें रोपणी, रोपवन और प्राकृतिक वन आ जाते हैं, पृथक किए गये *टैक्टोना ग्रांडिस* की जड़ों में आर्बुस्कुलर कवक मूलों के उपनिवेशीकरण और सागौन के पौधों में उनका टीका लगाने के प्रभाव का अध्ययन किया गया है । जड़ों में उनके उपनिवेशीकरण का प्रतिशत विभिन्न स्थानों में 25-95 के बीच में रहा । सामान्य वृक्षों की तुलना में आनुवंशिक दृष्टि से श्रेष्ठतर वृक्षों की जड़ों में उनका भारी उपनिवेशीकरण पाया गया । ग्लोमेल वंश की विभिन्न प्रजातियों अर्थात् *एकौलोस्पोरा*, *गिगास्पोरा*, *ग्लोमस*, *स्कुटेल्लोस्पोरा* और *स्क्लेरोसिस्टिस* । इनमें *ग्लो० एटुनिकेटम* और *एकौलोस्पोटा स्कोरोबिकुलाटा* के सोलह विभिन्न आबांलस्कुलर कवक पृथक करके पहचाने गए जिनकी *ग्लोमस इंड्रेडिसेस* और *ग्लो० मोसी* जातियाँ विस्तार से फैली हैं तथा *ग्लो० फैस्सीकुलेटम*. जाति कम फैली है । बिना टीका लगाए (नियामक) पौधों के मुकाबले में सागौन के पौधों में *ग्लो० फैस्सीकुलेटम* का अन्य आर्बुस्कुलर कवकों के साथ मिलाकर टीका लगाने से रोपणी अवस्था में वृद्धि, जैवपुंज और जड़ों में कवकों का संक्रमण अच्छा होता पाया गया । वृद्धि में त्वरा लाने और जैवपुंज बढ़ाने के लिए आर्बुस्कुलर कवकों का मिला-जुला टीका लगाना अधिक प्रभावकारी पाया गया ।

References

Boerner, R.E.J. (1990). Role of mycorrhizal fungus origin in growth and nutrient uptake by *Gerenium robertianum. Am. J. Bot.* **77** : 483-489.

Giovannetti, M. and B. Mosse (1980). An evaluation of techniques for measuring vesicular arbuscular infection in root. *New Phytol.* **84** : 489-500.

Hass, J.W. and J.A. Mange (1990). VA mycorrhizal fungi and soil characteristics in avacado (*Persea americana* Mill) orchard soils. *Plant Soil,* **127** : 207-217.

Mohankumar, V. and A. Mahadavan (1987). Ecological distribution of VAM in a tropical forest. A.K. Varma, A.K. Oka, K.G. Mukerji, K.V.B.R. Tilak and Janak Raj (Eds.) *Mycorrhiza Round Table Proc. Workshop* New Delhi. 238-256.

Michelsen, A. and S. Rosendahal (1990). The effect of VA mycorrhizal fungi, phosphorus and drought stress on the growth of *Acacia nilotica* and *Leucaena leucocephala* seedlings. *Plant Soil.* **124** : 7-13.

Phillips, J.M. and D.S. Hayman (1970). Improved proceduces for clearing and staining parasitic and vesicular arbuscular mycorrhizal fungi for rapid assesment of infection. *Trans. Br. Mycol. Soc.* **55** : 158-161.

Raman, N. and S. Gopinathans (1992). Association and activity of vesicular arbuscular mycorrhizae of tropical trees in a tropical forest of Southern India. *J. Trop. Forestry* **8** : 311-322.

Reena, J. and D.J. Bagyaraj (1990). Growth stimulation of *Tamarindus indica* by selected VA mycorrhizal fungi, *World J. Microbiology and Biotechnology,* **6** : 59-63.

Schenck, N.C. and Y. Perez (1990). *Mannual for identification of VAM fungi,* 3rd Ed. Synergistic Publ, Gainesville, Florida.

Thapar, H.S. and S.N. Khan (1973). Studies on endomycorrhiza in some forest species. *Proc. Indian Nat. Sci. Acad.* **39** : 687-694.

Verma, R.K. and Jamaluddin (1994). Effect of VAM fungi on growth and survival of *Acacia nilotica* seedlings under different moisture regime. *Proc. Nat. Acad. Sci, India.* **64(B)** : 205-210.

Walker, C., C.W. Mize and McNabb, H.S, Jr. (1982). Population of endogonaceous fungi at two locations in Central Iowa. *Can. J. Bot.* **60** : 2518-2529.

ASSESSMENT OF DAMAGE CAUSED BY HEART-ROT IN TEAK IN MADHYA PRADESH

N.S.K. HARSH AND C.K. TIWARI

Forest Pathology Division,
Tropical Forest Research Institute, Jabalpur (Madhya Pradesh).

Introduction

The standing tree is exposed to the risk of injuries by biotic and abiotic agencies throughout its life which open wounds in the tree tissues to be invaded by extraneous parasitic and saprophytic micro-organisms which grow, multiply and ramify causing death of living tissues and in many cases fungal decay of wood substances. Fungal decay reduces both the quality and quantity of timber and thus hampers the basic purpose of forestry which aims to produce crops of healthy timber. When decay is established in the heartwood and becomes progressive with time, it is termed as "heart rot" (commonly known as hollowness of tree trunks). Heart-rot is established in trees through wounds in the bark and Sapwood such as thinning, pruning and lopping scars, dead branches, branch stubs and knots, fire or grazing injuries and also in coppiced stands from the stool or thinning of the companion shoots. Since heartwoods of trees are prized for their grain patterns, strength and durability, heart-rot is considered of significant economic importance. Nearly 80% of the total loss of forest plants due to diseases, is attributed to heart-rot as determined from an appraisal of resources in the United States (Hepting and Jemison, 1958). Only in the U.S.A. have comprehensive estimates been prepared of losses due to heart-rot in the principal tree species (Findlay, 1956). Foster *et al.* (1954) estimated losses caused by heart-rot in *Tsuga heterophylla* (Raf.) Sarg. in British Columbia. In an appraisal of heart-rot in sal (*Shorea robusta* Gaertn.), Bakshi *et al.* (1963) found that out of 704 trees studied, 513 (73%) were affected with heart-rot entailing a loss of about 10% of the timber. This is the only appraisal available from India about the heart-rot damage. However, Singh *et al.* (1973) while studying the management of dry coppice teak forests in Gujarat had predicted that the incidence of heart rot may be as high as 50% but no estimation of damage was done.

Teak (*Tectona grandis* L.f.) is the most important and valuable timber species which contributes a major share in the forest revenue of Madhya Pradesh. During surveys of depots and forest areas it was revealed that teak is affected by heart-rot in stands. In the present study an attempt has been made to evaluate the damage caused by heart-rot in the timber in teak in Madhya Pradesh.

Materials and Methods

Estimation of heart-rot was done in the felling coupes of teak during felling and logging operations in Madhya Pradesh. The trees were then grouped in four girth classes. For the evaluation of loss in wood volume (decay cull), decay columns were measured in the depots in different grades (I, II, IIIA, IIIB and IV) following the method recommended by Bakshi (1977). To calculate the economics of losses, the production data for the year 1988 to 1991 and prevailing prices of Madhya Pradesh Govt. were taken into consideration.

Results and Discussion

The heart-rot damage assessment as measured in the felling coupes has been presented in Table 1.

It is evident from Table 1 that heart-rot infection increases with the increase in girth of the trees or with the age of the trees. Similar observations have also been made by Schmitz and Johnson (1927), McCallum (1928), Bier *et al.* (1948), Thomas and Podmore (1953), Boyce and Wagg (1953), Foster *et al.* (1954), Stillwell (1955), Thomas and Johnson (1958), Basham (1960) and Bakshi *et al.* (1963) in different tree species. The damage differs from locality to locality

Table 1

Heart-rot infection in felling coupes of Teak

Locality	Girth class (cm)	Heart-rot infected trees (%)	Total % of heart-rot infected trees
Kaladehi coupe IV	51 - 75	20.00	60.00
Bargi Range	76- 120	43.24	
Compt. No. 258	121 - 200	69.39	
Jabalpur Divn.	Above 200	76.92	
Padaria coupe IV	51 - 75	20.00	82.86
Kundam Range	76 - 120	63.64	
Compt. No. 236	121 - 200	86.36	
Jabalpur Divn.	Above 200	86.36	
Bedapar coupe VI	51 - 75	62.09	87.50
Chawar Range	76 - 120	83.33	
Sehore Divn.	121 - 200	98.97	
	Above 200	100.00	
Itarsi coupe IV	51 - 75	18.05	38.46
Taku - Kesla Range	76 - 120	30.00	
Hoshangabad Divn.	121 - 200	66.67	
	Above 200	69.23	
Rukhad 65 coupe	51- 75	32.43	48.39
Rukhad Range	76 - 120	45.45	
South Seoni Divn.	121 - 200	91.67	
	Above 200	100.00	
Multai coupe IV	51-75	22.47	62.67
Multai Range	76-120	45.11	
Betul Divn.	121 - 200	72.50	
	Above-200	76.15	

Table 2

Heart-rot damage assessment in stored Teak logs

Name of Depot	No. of logs sampled	Heart-rot % infected logs	Anticipated volume of all sampled logs (m^3)	Volume of infected logs (m^3)	Total volume of decay column (m^3)	Average % loss in wood volume in all logs	Average % less in wood volume in infected logs
Barghi Nagar Depot, Jabalpur	290	26.55	21.689	6.469	1.669	7.70	25.80
Kalpi Depot, Mandla	431	46.64	57.593	25.910	6.385	11.09	24.64
Hamlapur Depot, Betul	1281	45.75	104.944	54.962	14.563	13.88	26.50
Sehore Depot, Sehore	344	35.76	34.855	13.260	3.326	9.54	25.08
Ashapur Depot, Khandwa	184	48.37	11.544	6.583	1.931	16.73	29.33
Ralamandla Depot, Indore	138	38.41	6.112	2.947	0.832	13.61	28.23
Dhuma Depot, Seoni	241	27.39	16.735	4.109	1.132	6.76	27.55
Sironja Depot, Sagar	129	41.86	16.326	6.515	1.554	9.52	23.85
Pithora Depot, Raipur	171	42.69	21.998	8.990	2.877	13.08	32.00
Average of all Depots		39.27 %				11.32 %	27.00 %

and as observed ranges from 38.46% to 87.50% (Table 1). The localities in Chawar Range and Padaria Range were observed with clayey soils while the other localities were with murrumy soils. Peace (1938) reported that decay is greater on clay and less on sandy soils. Foster *et al.* (1954) also noticed similar variation with site conditions in *Tsuga heterophylla* and reported nearly 52% loss in wood volume due to heart-rot.

The results of evaluation of losses in wood volume (cull) have been depicted in Table 2. About 39% of stored teak logs were found affected by heart-rot in depots entailing a loss of about 11.32% in total log volume. However, in affected logs the loss in log volume was as much as 27%. According to Findlay (1956) by measuring the volume of decayed wood in sample logs after felling, reasonably accurate estimates can be made of both present and future losses due to decay in a stand.

Nearly 2.0 lakh m^3 of teak is extracted annually from the forests in Madhya Pradesh. At an average market price (1992-93) of about Rs. 9000/- per m^3 (average of all grades I-IV), the loss in wood volume due to heart-rot can be estimated to the tune of Rs. 19.80 crore rupees. Thus the loss is enormous in terms of wood volume lost due to heart-rot as well as in terms of revenue.

SUMMARY

Damage caused by heart-rot in teak trees in natural forest has been estimated in Madhya Pradesh (Central India) where 38% to 88% trees were found affected by heart-rot. Loss assessment made in stored teak logs in the depots revealed that about 39% logs were having heart-rot entailing an average loss of about 11% in wood volume. This loss in wood volume has been calculated to the tune of nearly Rs. 200 million annually on the basis of market value of teak.

मध्य प्रदेश में सार अपक्षयण से होने वाली सागौन की हानि का आकलन

एन०एस०के० हर्ष व सी०के० तिवारी

सारांश

मध्य प्रदेश (मध्य भारत) के प्राकृतिक वनों में सागौन के वृक्षों को सार-अपक्षयण से पहुंचने वाली हानि का आकलन किया गया है जहाँ 38% से 88% तक वृक्ष सार-अपक्षयण से ग्रस्त हुए पाए गए । भंडारों में रखाए गए सागौन के लट्ठों की हानि का अनुमान 39% लगाया गया है जहाँ सार-अपक्षयित लट्ठों से काष्ठ आयतन को लगभग 11% औसत हानि उठानी पड़ी । काष्ठ आयतन को पहुँची इस हानि का आगणन सागौन के बाजार भाव के आधार पर 20 करोड़ रु० वार्षिक लगाया गया है ।

Acknowledgements

The authors are thankful to Dr. B.N. Gupta, Director of the Institute and Dr. Jamaluddin, Head of the Division for kindly providing necessary facilities and encouragements.

References

Bakshi, B.K. (1977). *Disease insect survey-Manual of Instruction.* F.R.I., Dehra Dun.

Bakshi, B.K., P.S. Rehill and T.G. Choudhury (1963). Field studies on heart-rot in sal (*Shorea robusta* Gaertn.) *Indian Forester,* **89** : 1-17.

Basham, J.T. (1960). Studies in forest pathology. XXI. The effects of decay on the production of trembling aspen pulpwood in the upper Pic region of Ontario. *Publ. Dep. Agric. Can.* 1060, 25 p.

Bier, J.E., P.J. Salisbury and R.A. Waldie (1948). Studies in forest pathology. V. Decay in fir *Abies lasiocarpa* and *A. amabilia,* in the upper Fraser river of British Columbia. *Tech. Bull. Dep. Agric. Can.* 6828 p.

Boyce, J.S. and J.W.B. Wagg (1953). *Conk rot of old growth Douglas fir in Western Oregon.* U.S. For. Serv. For. Prod. Lab. 496 p.

Findlay, W.P.K. (1956). Timber decay-a survey of recent work. *For. Abstr.* **17**: 317-327.

Foster, R.E., H.M. Craig and G.W. Wallis (1954). Studies in forest pathology. XII, Decay of western hemlock in the upper Columbia region, British Columbia, *Can. J. Bot.* **32** : 145-171.

Hepting, G.H. and G.M. Jemison (1958). Forest protection. Timber resources for America's future. *For. Resour. Rep. U.S. Dep. Agric. For Serv.* **14** : 158-220.

McCallum, A.W. (1928). Decay in Balsam fir (*Abies balsamea* Mill.) *Bull. Can. Dep. Agric.* (N.S.) 104. 25 p.

Peace, T.R. (1938). Butt rot of conifers in Great Britain. Quart. *J. For.* **32** : 81-104.

Schmitz, H. and A.L. Johnson (1927). Decay in young Western larch in British Columbia. *Bi-m. Prog. Dep. Div. For. Bio. Dep. Agric. Can.* **14** : 3-4.

Singh, Sujan, Y.N. Puri and B.K. Bakshi (1973). Decay in relation to management of dry coppice teak forests. *Indian Forester,* **99 (7)** : 421-430.

Stillwell, M.A. (1955). Decay of yellow birch in Nova Scotia. *For. Chron.* **31** : 74-83.

Thomas, G.P. and A.L. Johnson (1958). Decay in young Western larch in British Colombia. *Bi-m Prog. Dep. Div. For. Biol. Dep. Agric. Can.* **14** : 3-4.

Thomas, G.P. and D.G. Podmore (1953). Studies in forest pathology. XI. Decay in black cotton wood in the middle Freser region, British Colombia. *Can. J. Bot.* **3** : 675-692.

TEAK FRUIT TREATMENT MACHINE - A PROTOTYPE - II

A.R. BAPAT* AND M.M. PHULARI**

Maharashtra Van Sanshodhan Sanstha,
Chandrapur (Maharashtra).

Teak is a universal timber species par-excellence. Durability, strength properties, workability, figure, polishing qualities and versatile utility offer teak timber this distinctive position in world-wide timber trade. Market-rates steadily rising but stable, reaching sky-heights and ever widening gap between demand and supply are clear manifestation of its paragon timber values. Massive teak plantations have been and would be taken in India and abroad in most of the isoclimatic regions of the World.

The paragon timber qualities of teak received recognition far early in the history of scientific forestry development. Teak plantations were taken in the past to enrich forests, since over and a half centuries. Besides there are vast areas over 9.77 million ha under natural teak forest in our country. Conservation and management of those for progressively increasing and on sustained basis, teak plantations on an average over 82,000 ha, are being taken annually. It is imperative to raise at least 21 million seedlings, and that we have to handle over 1640 MT of Teak seed annually. Requirement of quality good seed is going to continue in perpetuity.

Teak fruit/seed bears a thick, hard and felty cover mesocarp. The mesocarp is responsible for inhibition of seed germination. Teak fruits are therefore, subjected to various treatment methods before in the nursery beds to get high germination percentage. Various methods of pretreatment have been developed and are traditionally in practice. The simplest one being alternate soaking, drying. In pit-method fruit mesocarp is subjected to decay by burying seeds in pit with cow-dung slurry for three weeks. Acid treatment to burn mesocarp is another method. All these methods are having various limitations. They are adhoc, elaborate, time-consuming and with an element of subjective skill and experience. The pretreated seeds are not of gauged standards, effective qualitatively and with timely assured bulk supply. There are lot of wastage and spilling over of seed during the process at number of stages due to handling. The process is elaborate, laborious and expensive.

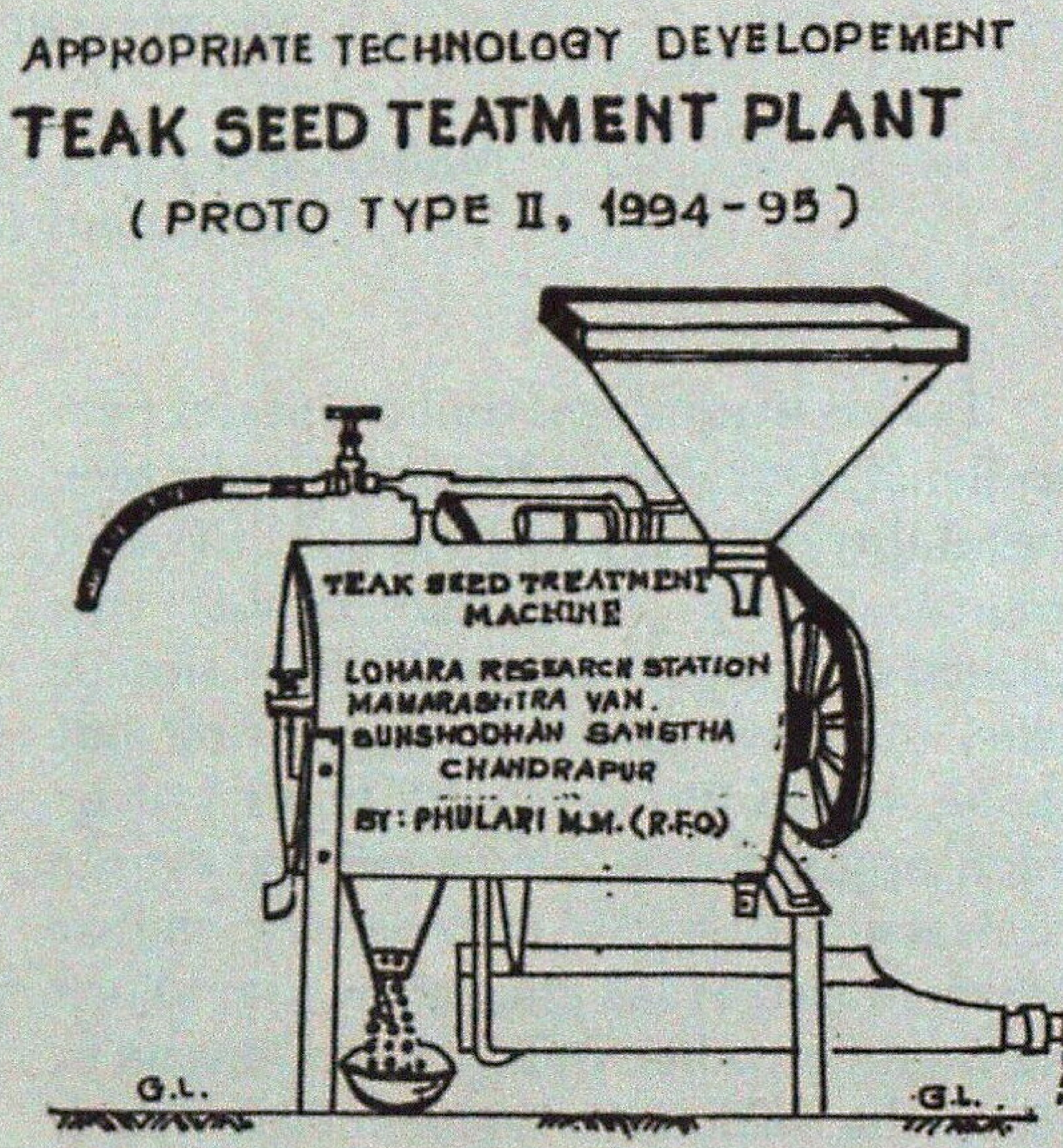
A Vast stretches of Teak forests are being managed scientifically since long, there has been a bottleneck in getting quality pretreated seeds for raising massive seedling stock of Teak. This lacuna received attention of Maharashtra Van Sanshodhan Sanshta, Chandrapur since past few years. A mechanical simple device was evolved, on the pattern of concrete mixing-millermachine, for teak seed treatment viz. Teak fruit treatment machine - A prototype, (Grewal *et al.,* 1993). While handling this machine certain practical difficulties and shortcomings were experienced. In this device for treatment, teak fruits, sand and metal, mixed in equal proportion i.e. 1 : 1 : 1 ratio, was required to be placed for churning for about 2 hrs. After treatment, it was difficult to separate seed from mixture. The heavy load of charge after repeated short use to treat about one tonne of seed, was found to cause irreparable damage and required replacement. Machine was unsuited for small quantities i.e. less than about 10 kg. The study and experience gained in the process, institute succeeded in developing another appropriate technology device viz. the present "Teak Fruit treatment Machine - A prototype - II", the new machine is easy to handle and has now clearly removed the snags in the pretreatment process of teak seed.

---

* Director and Silviculturist, ** Research Range Forest Officer

The new prototype-II is a simple machine, on the pattern of an ordinary floor-mill, and very easy to handle. It consists of a outer drum 53 cm long and 40 cm diameter mounted on angle iron frame with an axle. Axle ends are fitted with bearings to reduce the friction when set into rotation. The outer drum has two openings, one at right hand top provided with hopper, serving as "Inlet" while other at left hand bottom fitted with channel to serve as an "Outlet", for seeds. For the constant supply of water, a pipe with two inlets is fitted lengthwise at the top of the outer drum. On the lower side of the drum seven rows 1 x 1 cm apart and 1 cm long slit openings are provided. The edges of the slits are kept slightly projecting inside. The slit arrangement serves dual purpose of rough surface for scraping seed while in rotating motion and as drain out for worn out slushy mesocarp and water (Fig. 1).

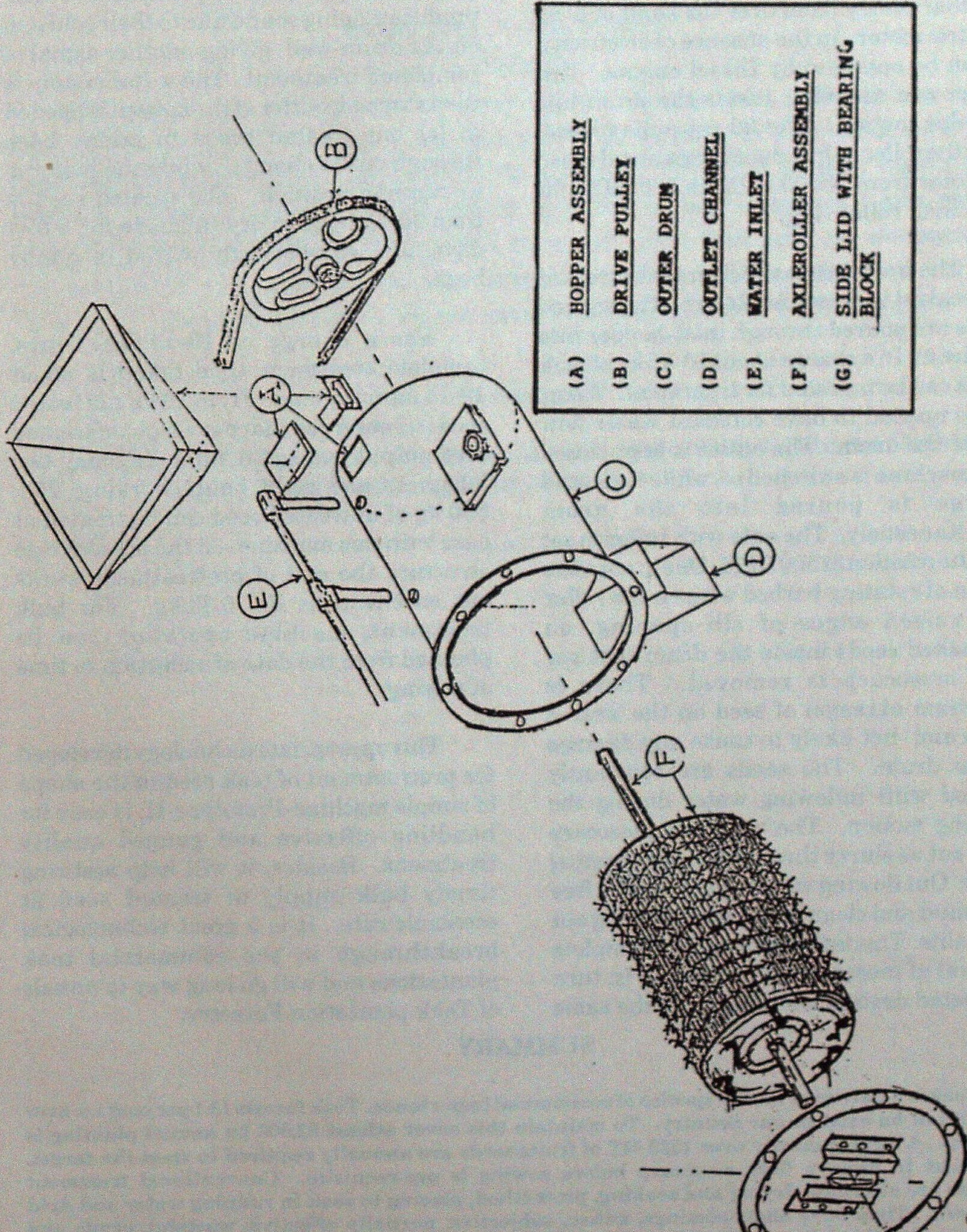
Fig. 1



The axle passing through the horizontally placed outer drum is fitted with firm wooden hub. For firm grip, axle is actually passed through a wooden roller made up of *Chloroxylon sweitenia* wood. For perfect shape, wooden roller was moved on a lathe machine. Roller has 27 cm dia while 38 cm length, much less than outer drum length for free rotation. On the wooden roller, 12 x 12 gauge barbed wire is tightly wrapped and fixed with "U" nails. Distance between two rows is kept 1 cm apart. The outer drum and inner roller is adjusted in such a way that free allowance between them is kept about 4-5 cm. One end of the roller is provided with 4 steel plates projecting 6 cm cut to avoid accumulation of teak fruits between drum-wall and end of roller (Fig. 2).

One end of the axle is provided with pulley wheel of size 30 cm dia. The pulley

Fig. 2


(A) HOPPER ASSEMBLY
(B) DRIVE PULLEY
(C) OUTER DRUM
(D) OUTLET CHANNEL
(E) WATER INLET
(F) AXLEROLLER ASSEMBLY
(G) SIDE LID WITH BEARING BLOCK
A
B
C
D
E
F
G

Teak Seed Treatment Plant

wheel in turn is linked by "V" belt, to another pulley fixed over the shaft of 2 HP electric motor. In the absence of electricity, it can be operated by Diesel engine. This motor can set roller inside the drum into circular motion. The 30 cm pulley wheel over the roller help reducing rotational speed of motor from 15000 RPM to 500 RPM for axle with roller (Fig. 1).

The fruits/seeds which are to be treated are soaked in water for 24 hrs. The soaked seeds are poured through inlet-hopper into the drum. In a charge about 10-13 kg of teak fruits can be ingested for treatment. Water tap is opened to have constant water flow inside the drum. The outlet is kept closed and machine is switched on while teak seed charge is poured into the drum simultaneously. The axle with roller is set into the rotation at 500 RPM. Due to abrasive action of rotating barbed wire on the roller and raised edges of slit-opening, on presoaked seeds inside the drum cent per cent mesocarp is removed. There is minimum abrasion of seed on the wall of drum and not likely to cause any damage to the drum. The seeds are constantly washed with inflowing water during the rotating motion. The worn out mesocarp flows out as slurry through the slit-opening below. Out flowing water soon becomes free from mud and clean water start flowing out of the slits. This is the indication of complete removal of mesocarp of fruits, and in turn completed desired treatment. At the same moment, hard endocarp exposed seeds, produce ringing sound due to their collision on the drum-wall, giving another signal of completed treatment. The water supply is then stopped, outlet at the bottom is opened to let out treated seeds in gunny bags through outlet channel, while the motor is in running position. The treated seed is then spread out to dry in shade for 3 to 4 days, and subsequently stored in gunny bags.

For a charge of 10-13 kg, fruits, complete treatment time taken is about 10-15 minutes only. From 10 kg untreated seed it is observed that net weight of treated seed output is 6 kg i.e. 60 %. In a day two labourers and eight hours working, 250-300 kg of untreated seed can be treated at ease with this machine. At the present rate structure the cost of pretreatment works out as cheap as Rs. 0.30/kg. For bulk treatment, machine operation can be planned from the date of collection to time of sowing.

This appropriate technology developed for pretreatment of teak seed in the shape of simple machine-Prototype-II, is easy for handling effective and gauged quality treatment. Besides, it will help assuring timely bulk supply of treated seed at economic rate. It is a great technological breakthrough in the commercial teak plantations and will go long way in annals of Teak plantation Forestry.

SUMMARY

Teak is a universal timber species of commercial importance. Teak forests 13.1 per cent i.e. over 9.77 million ha exist in our country. To maintain this cover atleast 82,000 ha annual planting is essential. A large quantity over 1628 MT of fruits/seeds are annually required to meet the target. Treatment to remove felty mesocarp before sowing is pre-requisite. Conventional treatment methods are alternate drying and soaking, pit-method, placing to soak in running water and Acid treatment. They have short-comings, adhoc, subjective, partially effective, wasteful, crude and elaborate, lengthy, labour intensive and costly. Innovative treatment plant has been successfully fabricated.

सागौन के फलों का उपचार करने वाल यन्त्र प्राग्रूप-2

ए०आर० बापट व एम०एम० फुलारी

सारांश

सागौन व्यापारिक महत्व की विश्व भर में फैली प्रकाष्ठ जाति है । सागौन के 13.1% अर्थात् 97.7 लाख हेक्टेयर में फैले वन हमारे देश में मिलते हैं । इतना वन सतत बनाए रखने के लिए कम से कम 82 हजार हेक्टेयर क्षेत्र में उसका प्रतिवर्ष रोपण करते जाना अनिवार्य है । इस लक्ष्य की प्राप्ति के लिए 1628 मीटरी टन से भी अधिक फल/बीज प्रतिवर्ष चाहिए । बीज को बोने से पूर्व उसकी नमदे जैसी मध्यभित्ति को निकालने का उपचार आवश्यक है । इसके पारम्परिक उपचारों में बीज को क्रम से सुखाना और भिगोना, गढ्ढे में डालना, बहते पानी में भिगाने डालना और अम्ल उपचार आते हैं । इनकी कमियाँ हैं - तदर्थ व्यक्तिपरक होना, अंषतः प्रभावकारी होना, बरबादी परक, भौंड़ा, अधिक समय लगने वाला, अधिक श्रम चाहने वाला और महंगा होना । एक नया उपचार संयंत्र सफलतापूर्वक तैयार कर लिया गया है ।

Reference

Grewal, J.S., Anmol Kumar and S.R. Gaikwad (1993). Teak Fruit Treatment Machine - A Prototype. *Indian Forester,* **119** (3) : 352.

THE VIABILITY OF COMMERCIAL TEAK PLANTATION PROJECTS

A.N. CHATURVEDI

Tata Energy Research Institute, New Delhi

Several Companies have come up during the last couple of years advertising very high profits on investments in teak plantations. During 1981-90, similar such Companies based on Eucalypt plantations were advertised. The people who invested on these high density high profile Eucalypt plantations suffered heavy losses and practically all such companies have closed down. Forestry is largely a state subject in India and there are practically no private companies involved exclusively in forest plantations. No expertise is, therefore, available except in the Forest Departments. It is necessary for investors and the general public to understand the basic technical aspects of such plantation projects. The forest trees are long-lived. The felling age of trees is not governed by their physical age. The trees grow differently at different ages and the wood quality changes with age and rates of growth. The felling age called the rotation of harvest, therefore, depends on the rate of growth, quality of wood and the market demand.

Teak is India's best known timber and is used as a standard for comparing all other tree species for their timber quality. Regular teak plantations were started in India in the year 1842. Teak is amongst the best studied and researched tree species. Every aspect of its cultivation and harvest is known and well documented. During the last four years, large number of financial companies have grown up in India and crores of rupees have been invested by thousands of people who expect to reap huge benefits. The arguments in favour of teak investments advertised by these companies are, in general, on these lines :

(i) The plantations will be raised from seedlings which will be converted to stumps (root shoot cuttings).
(ii) 1500 stumps will be planted per acre i.e. a spacing of 1.65 m x 1.65 m.
(iii) The first thinning of 3 years age will reduce the number to 1250 i.e. a spacing of 1.80 m x 1.80 m.
(iv) The 2nd thinning at 6 year age will further reduce the number to 500 i.e. 2.83 m x 2.83 m.
(v) The 3rd thinning at 12 years age will bring down the number to 375 trees i.e. 3.30 m x 3.30 m.
(vi) 375 trees will be retained for final harvest at 20 years.

The Companies project to harvest 375 trees yielding 1.05 m^3 of timber per tree i.e. about 393.75 m^3 per acre. It is stated that the price of the harvested wood will be Rs. 62,500 per tree i.e. Rs. 60,000 per m^3. The present price of about Rs. 57,000 per m^3 is for first quality teak logs in sale depots and not for whole wood of standing tree.

Growth data on teak plantations in India have been collected for 80 years. These have been analysed and yield tables for plantation teak have been published by the Forest Research Institute. Teak plantations in India are divided into four site quality classes I, II, III and IV depending on growth which varies according to edapho-climatic conditions. The best quality is I and the poorest is IV. Intermediate classes I/II, II/III and II/IV are also recognized. Thus, 7 site quality tables are available. These tables give per acre figures of average diameter, average height, number of trees and volume from 5 to 80 years at five year intervals. After many trials, the most widely adopted spacings in forest plantations is 1.83 m x 1.83 m i.e. 1200 stems per acre. In I quality, this number is reduced to 539 in the 5th year. This also accounts for the seedlings which die naturally during this period. Thinnings are carried out at five yearly intervals and the number of trees left standing at 10 years is 256, at 20 years are 102, at 40 years 46, at 60 years 35 and at 80 years 31. The standing timber volume per acre at 20 years is 23.80 m^3 (0.24 m^3 per tree), at 40 years it is 72.80 m^3, at 60 years it is 1233.18 m^3 (3.22 m^3 per tree) and at 80 years, it is 4840 (4.37 m^3 per tree). The Companies project at 20 years 375 trees with average volume of 1.05 m^3 per tree i.e. 394 m^3 per acre. This volume at 20 years is 16 times more than that obtained in the best plantations raised in India. 1.05 m^3 volume of a tree corresponds to a tree of 1.53 m girth class or about 20 inches (50 cm) diameter. Average diameter of 20 inches in Ist quality teak is obtained in about 45 years at this age, the number of trees per acre is 41. Trees are measured for girth or diameter at 1.38 m above ground referred to as girth or diameter at breast height.

By increasing the inputs of irrigation and frequent thinnings, it is possible to increase the rate of diameter growth. The increase in diameter growth is, however, dependent on increasing the size of the crown i.e. decrease in the number of trees per acre. This will mean that the high expected volume in individual trees is possible only if the number of standing trees per acre is proportionately reduced. The increase in number of the trees per acre cannot be simultaneously increased along with the girth of trees. One can have either lesser number of trees of higher girth or larger number of trees of lower girth. The increase in both the number of trees per acre to 375 as well as yielding 1.05 m^3 per tree at 20 years is not feasible. Trial irrigated plantations of teak were carried out at several places in India during 1928 to 1930. It was found that these trees grew faster but the sapwood content of trees increased, the wood became weak and wind damage became quite serious. A phenomenon of water blisters was also noticed in several trees grown under irrigated conditions. Such trees appeared to be quite healthy from outside but the inner heartwood developed rot due to the storage of excess water that increased the spread of fungi. Teak does not grow well on degraded lands and water logged sites. Teak trees require reasonably fertile humus rich, well drained sites, for good growth.

It is also advertised that these trees are being fertilized and irrigated. Drip irrigation will induce surface roots and epicormic branching. Nitrogen fertilizers will increase the nitrogen content of leaves. Initially larger leaves will increase photosynthesis and faster growth. By about five years the dreaded defoliators and skeletoniser *Hyblaea puera* and *Hapalia machaeralis* would attack these plantations. These will drastically reduce the photosynthesising leaf surface. These insects have about 14 life cycles in a year. The control through insecticides is not, therefore, possible. The damage incidence is higher when trees grow closer. During heavy attacks the loss of upto 65% of growth has been recorded in the past. The attack can reduce both diameter and height growth. The pests associated with trees always follow plantations and they cannot be wished away. In forest plantations, there are many natural enemies of these insects which live on trees of other species. Since these teak plantations are being raised far away from natural forest areas, it will take several decades by the time adequate populations of the parasites of these insects are built up.

The teak wood produced in these plantations is going to have a very high percentage of sapwood which is not durable. The quality of wood is going to be inferior. The faster growing teak grown in Kerala, therefore, fetches a lower price than the slower growing CP teak. The girth of sections of a tree reduces with height. The lowest butt portion of the tree produces the best timber of the highest size. This fetches the highest price. The per m^3 price of wood reduces from the thick to thin end. In the financial benefits, the promoters are considering the entire wood of the tree to be similar and of high timber quality. The timber quality portion of wood in a tree depends on size of the tree. It varies from 20 % in young trees to about 40 % in mature tree. The top portion and branches of trees are sold only as firewood which will fetch about Rs. 1000 per m^3 even in teak. Average price per m^3 for the total wood of the tree will not be more than about 20 % of the price of 1st class logs i.e. in a tree of 1.05 m^3 not more than 0.28 m^3 will be of timber quality. Thus even if the price of teak timber is Rs. 59,000 per m^3 the whole tree containing 1.05 m^3 will not fetch more than about Rs. 16,000/- against an expectation of Rs. 62,000. Rs. 1275/- per tree which the Companies are asking the investors to deposit will in 20 years become Rs. 12,299/- and Rs. 20,867/- at compound rate of interest of 12 and 15 per cent respectively. Nursery cost of a teak stump is about Rs. 2.50. The planting cost will be about Rs. 4.50. The land taken in the beginning remains as such at the end of the plantation. The investment of Rs. 1275 per tree is, therefore, disproportionate to the actual planting cost of Rs. 7/- per plant. The whole project is not technically sound. The investors may get back advertised returns on their investment but it cannot be from sale of teak wood produced in these plantations.

SUMMARY

The basic technical aspects of viability of commercial teak plantations are described in this paper.

सागौन की व्यापारिक रोपवन परियोजनाओं की जीवनशक्यता

एन० चतुर्वेदी

सारांश

इस अभिपत्र में व्यापारिक सागौन रोपवनों की जीवनशक्यता के आधारभूत प्राविधिक पक्षों को वर्णित किया गया है ।

VALUE OF A 20 -YEAR OLD IRRIGATED TEAK PLANTATION

J.K. RAWAT*

Several firms/financial companies have, in the last few years, initiated projects asking people to invest Rs. 500 to Rs. 1000 in a teak tree that will give them a return of Rs. 50,000 to Rs. 1,00,000 in 20 years. The projects claim to use improved planting stock, drip irrigation and fertilizers that will give their plantations a high rate of growth. These claims need to be investigated. In this paper, growth and yield data available for teak plantations and price and price-trends for teak wood have been used to estimate the value of a 20-year old irrigated teak plantation.

The growth and yield of teak plantation has been thoroughly studied by the Forest Research Institute. A large number of permanent sample plots have been laid out in teak plantations in different sites/zones of the country. On the basis of data recorded at these plots, "Yield and Stand Tables for Teak" was published by Forest Research Institute in 1959. However, this and other publications on teak are for plantations raised under rainfed conditions and no long term growth data are available for irrigated teak plantations. Irrigation and other inputs to a plantation are likely to give it a better survival rate and a higher initial growth. For the sake of analysis, it is reasonable to assume that in 5 years time such plantations may attain growth observed in a 10-year old plantation raised under rainfed conditions. Once the trees are established they generally do not respond significantly to irrigation and fertilizers. Thus, an irrigated plantation has been assumed to attain a growth in 20 years which is attained by a normal plantation in 25 years. In other words, the value of a 25-year old plantation obtained from our analysis can be said to represent the value of a 20-year old irrigated crop of teak.

The steps involved in this study consist of estimating yields, prices and, consequently, values of wood output from the teak plantation. The published yield data usually give volume of timber (for logs of girth over 60 cm) and small-wood. However, the price of teak wood has been found to vary appreciably with the size of stem. Therefore, for a proper valuation of teak trees and stand, further categorization of timber is necessary. Thus, modified volume table for teak was constructed showing separate volumes of timber obtained from logs between 60 to 90 cm girth, 90 to 120 cm girth and for girths greater than 120 cm.

To begin this exercise, the stand table developed for teak (Anon, 1959), part of which is shown in Table 1 was used to obtain a clearer picture of standing crop. It has been shown that the distribution of trees by diameter classes is largely independent of site quality and is primarily a function of average crop diameter.

---

* Presently Conservator of Forests, Social Forestry, Rohtak (Haryana).

Table 1

Stand table for plantation Teak

Crop Dia	Per cent of trees within diameter class (cm)									
	>5	5-10	10-15	15-20	20-25	25-30	30-35	40-45	45-50	Total
20	0	6	36	45	11	2	0	0	0	100
25	0	1	9	36	38	13	2.5	0.5	0	100
30	0	0	2	11	32	33	17	4	1	100

Table 2

Modified Volume Table for Teak

DBH (cm)	Timber volume under-bark for girths				Small wood over-bark (m^3)
	60-90 cm (m^3)	90-120 cm (m^3)	over 120 cm (m^3)	Total (m^3)	
15	0	0	0	0	0.110
20	0.042	0	0	0.042	0.201
25	0.154	0	0	0.154	0.185
30	0.376	0	0	0.376	0.170
35	0.419	0.254	0	0.673	0.154
40	0.366	0.450	0.200	0.015	0.139
45	0.305	0.490	0.608	1.403	0.123
50	0.238	0.534	1.064	1.837	0.107

Detailed volume data of about 100 trees harvested in the sample plots distributed all over the country were used to develop relationships between volumes and diameter at breast height (DBH). These were used to construct the modified volume table for teak (Table 2).

The past and current prices of teak timber were obtained from various forest depots and timber markets. It was observed that the timber price in Gujarat increased at the rate of 17 per cent per annum during 1975-87, in Kerala by 13 per cent per annum during 1990-1991, in Andhra Pradesh by 20 to 22 per cent per annum during 1973-89, in Maharashtra by 12 per cent per annum during 1982-85, in Uttar Pradesh by 18 per cent per annum during 1980-90 and in Orissa by 14 per cent per annum during 1968-84. Thus, we find that the teak timber prices have increased at annual rates 12 to 18 per cent or say 15 per cent per annum during the last decade. Since our aim is to estimate the value of teak crop, planted today, 20 years from now, we have to estimate the teak prices that will be prevalent at the end of 20 years. For this, we have to forecast the price trend or the annual rate at which price is likely to increase in future. For want of any econometric study on this subject, we may assume that the price trend will be nearly same as in the past, i.e. an increase of 15 per cent per annum. But, there are greater chances of it to be lower than 15 per cent per annum due to (i) greater anticipated supply of teak wood in future (likely to be obtained from social forestry plantations raised during the 1980s), and (ii) the increased availability of substitute furniture and construction materials such as medium density fibreboard. Thus, a lower rate of escalation, say at 10 per cent or 12 per cent per annum, keeping pace with the general rate of inflation, is more likely. However, in this analysis, value projections have been made for all the three price escalation trends.

The current prices of teak timber vary to some extent from region to region and from depot to depot. However, a reasonable average price of Rs. 10,000 per m³ for a log of 60-90 cm girth, Rs. 11,000 per m³ 90-120 cm girth, Rs. 12,500 for logs greater than 120 cm girth and Rs. 2,500 per m³ for small-wood (containing poles and small timbers etc.) can be taken as the base price. These prices and prices anticipated 20 years from now at different rates of price escalation are presented in Table 3.

Based on the above prices value table for teak has been developed and presented in Table 4. It shows the value of a teak tree of a given DBH at current and future anticipated prices.

Data of age, crop diameter, average

Table 3

Price of Teak wood (Rs/m³)

Category	Average current price	Price estimated for 20 years from now @ price escalation		
		10%	12%	15%
Small wood	2,500	16,800	24,100	40,900
Girth 60-90 cm	10,000	67,300	96,500	163,700
Girth 90-120 cm	11,000	74,000	106,100	180,000
Girth over 120 cm	12,500	84,100	120,600	204,600

Table 4

Value table for Teak ('000 Rs/Tree)

DBH (cm)	At average current prices	At prices estimated for 20 years from now @ price escalation		
		10%	12%	15%
15	0.3	1.9	2.7	4.5
20	0.9	6.2	8.9	15.1
25	2.0	13.5	19.3	32.7
30	4.2	28.2	40.4	68.5
35	7.4	49.6	71.1	120.6
40	11.4	77.0	110.4	187.3
45	16.3	110.0	157.7	267.6
50	21.8	146.9	210.6	357.3

height, density of stocking and site quality for different regions of the country were obtained from the permanent sample plots existing in these regions. Data were taken from the records of sample plots in Buxa Division (West Bengal), Wynaad Division (Kerala), South Chanda Division (Maharashtra), South Coimbatore Division (Tamil Nadu), North Raipur Division (Madhya Pradesh) and Forest Research Institute, Dehra Dun (Uttar Pradesh). These plots belong to the sites of Quality II and III, the type of sites that are generally available for teak plantations and are likely to be used for teak projects. These data, in combination with stand table, modified volume table and price/volume table, helped in providing relationship between value (VAL) of teak crop as a function of age (T) and density (N). A total of 35 observations were used where T ranged between 11 and 54 years and N ranged between 140 trees/ha and 924 trees/ha. The estimated regression equations are given below (All the coefficients were significant at 95 per cent confidence level, coefficient of determination was 0.71 and there were 32 degrees of freedom).

At current prices: (1n : log natural)

$$\text{1n}(\text{VAL}) = 7.537 + 0.887\,\text{1n}(T) - 0.719\,\text{1n}(N)$$

At prices 20 years from now with rate of price escalation as :

(i) 15 per cent per annum :

$$\text{1n}(\text{VAL}) = 10.333 + 0.887\,\text{1n}(T) - 0.719\,\text{1n}(N)$$

(ii) 12 per cent per annum :

$$\text{1n}(\text{VAL}) = 9.445 + 0.887\,\text{1n}(T) - 0.719\,\text{1n}(N)$$

(iii) 10 per cent per annum :

$$\text{1n}(\text{VAL}) = 9.805 + 0.887\,\text{1n}(T) - 0.719\,\text{1n}(N)$$

Table 5

Value of 20-year old irrigated teak plantation ('000 Rs)

Density at 20 yrs (trees/ha)	Value item	At current prices	At prices estimated for 20 yrs from now @ price escalation		
			10%	12%	15%
250	Crop/ha	615	4,137	5,933	10.066
	avg. tree	2.5	16.6	23.7	40.3
300	Crop/ha	539	3,628	5,203	8,829
	avg. tree	1.8	12.1	17.3	29.4
350	Crop/ha	483	3,247	4,657	7,902
	avg. tree	1.4	9.3	13.3	22.6
400	Crop/ha	439	2,950	4,231	7,178
	avg. tree	1.1	7.4	10.6	18.0
450	Crop/ha	403	2,710	3,887	6,595
	avg. tree	0.9	6.0	8.6	14.7
500	Crop/ha	374	2,512	3,603	6,114
	avg. tree	0.8	5.0	7.2	12.2

The lower densities give higher value of the crop because of greater size of trees. However, densities below 250 trees/ha at age 20 years is not likely to completely cover the canopy. The above relationships were used to estimate the value of 25-year old crop for various final densities and different rates of anticipated price escalation (It may be noted that yield/value estimated at age 25 years was presumed to represent yield/value from a 20-year old irrigated plantation). The expected values are given in Table 5.

It is found that the highest value of average teak tree (obtained for density of 250 trees/ha and anticipated price escalation of 15 per cent per annum) is only Rs. 40,000. At a reasonable rate of price escalation, the value of average tree will be below Rs. 25,000.

It may be noted that this analysis does not study the economics of teak planting. The latter will involve the cost of planting, land cost, cost of supervision and management, choice of discount rates, intermediate returns (from thinnings and other uses of plantation area, such as recreation, camping and wildlife), choice of optimal rotation age, etc.

SUMMARY

In this paper, growth and yield data available for teak plantation and price and price trends for teak wood have been used to estimate the value of a 20-year old irrigated teak plantation are given.

बीस वर्ष में सिंचित सागौन रोपवन का मूल्य

जे०के० रावत

सारांश

इस अभिपत्र में एक 20 वर्षीय सिंचित सागौन रोपवन के मूल्य का अनुमान लगाने के लिए सागौन रोपवनों के वृद्धि और प्राप्ति आंकड़ों तथा सागौन काष्ठ के मूल्य और मूल्य प्रवृतियों को उपयोग में लाया गया है ।

Reference

Anon. (1959). Yield and stand tables for plantation teak. *Indian For. Rec.* **9** (4). 151-216. Forest Research Institute, Dehra Dun.

TECTONA GRANDIS - ELITE MANAGEMENT

R.S.R. PRASAD*

Objectives

(a) To give government immediate revenue of Rs. 90 crores of Rupees in every year without cutting any forest tree and a portion of this revenue as foreign hard currency from NRI investors, from only 3000 ha of Teak Plantations out of the 75000 ha owned by the State of Kerala.

(b) Improving the growth of Teak plantation for much more increment to get much more revenue when it is harvested.

(c) Eco-development of areas under Teak plantations by giving better Silvicultural management to Teak (Spraying, Manuring, Fire protection etc. as well as Soil and Moisture conservation treatments).

(d) Getting funds from public for better Silvicultural management and development of forests.

(e) To encourage people's participation in Forest Management.

(f) Reduction of theft in theft-prone areas by better and intensive management.

(g) To reduce damage of Teak Stands by biotic interference and better management of the area by giving them elite treatment.

(h) To earn huge foreign currency from NRIs in the long run.

Table 1

Prepared from data from
Nilambur area -Yield table

Site Quality I Area :

(a) Age of Teak trees = 40 yrs
No. of Stands = 170 /ha
Total volume of solid timber = 458 m^3 /ha
(b) Age of Stand = 45 yrs
No. of Stands = 153 /ha
Total volume of solid timber = 500 m^3/ha
(c) Age of Stand = 50 yrs
No. of Stands = 138 /ha
Total volume of solid timber = 538 m^3/ha

Inference

Total increment of Timber in 10 yrs = 82.1 m^3/ha
Increment in 5 years plantation from 45 year old = 39.35 m^3/ha

Site Quality II Areas :

(a) Age of Stand = 40 yrs
No. of Trees = 207/ha
Total volume = 325 m^3/ha

---

* Conservator of Forest and Director, Nature Study Park, Kalady (Kerala).

(b) Age = 45 yrs
No. of Trees = 185/ha
Total Volume = 355.8 m^3/ha
(c) Age = 50 yrs
No. of Trees = 168/ha.
Total Volume = 383 m^3/ha

Inference

Total increment in 10 yrs = 60 m^3/ha
Total increment in 5 yrs = 28 m^3/ha

Site Quality III Areas :

(a) Age = 40 yrs
No. of Trees = 269/ha
Total Volume = 192 m^3/ha
(b) Age = 45 yrs
No. of Trees = 237/ha
Total Volume = 211 m^3/ha
(c) Age = 50 yrs
No. of Trees = 212/ha
Total Volume = 229 m^3/ha
Increment available in 10 years = 38.42 m^3/ha
Similarly increment available in 5 years = 18.28 m^3/ha

N.B. : Data have been rounded to approximation.

Discussion

When the plantation of one ha area becomes 50 years old from 40 years, the volume of timber increases by :

82 m^3 in Site I area per ha
60 m^3 in Site II area per ha
40 m^3 in Site III area per ha

We can increase this increment manifold by reducing the damage of No. of trees during 10 years by fencing, better protection and better silvicultural management like fire protection, spraying, climber cutting, manuring etc. So, when the plantation becomes 50 years from 45 years, the volume of timber available increases by:

82 m^3/ha in Site I
60 m^3/ha in Site II
40 m^3/ha in Site III.

When plantation becomes 50 years from 45 yrs., volume of timber increases by :

40 m^3/ha in Site I
28.78 m^3/ha in Site II
18.28 m^3/ha in Site III.

We are harvesting Teak after 50 years in Nilambur area. We can take 45 year old Teak Plantation and 40 year old Teak plantations for our scheme. As discussed in the last paragraph, we can increase the increment many times as these plantations reach their 50th year by timely manuring, spraying, fencing, etc.

From 40 year old plantations, we get an average minimum increase of 60 m^3/ha by proper selection of areas in the next 10 years.

From 45 year old plantations, we get an average minimum of 30 m^3/ha by proper selection in 5 years.

These amounts can safely be obtained in any case in normal course in the next 10 years and 5 years. In fact, even after supplying this, we can give much, much more revenue than the Government could have got in the normal course, from those plantations which are proposed to be put under elite treatment and growth increment will increase manifold as discussed in the above paragraphs.

To conclude from 40 year old plantations we can safely promise to investors 60 m^3/ha after 10 years and from 45 years old plantations, we can safely promise 30 m^3 of timber from one ha, when the plantation are to be harvested, and give the Government much more than what it would get at the time of harvesting in future too, besides this quantity.

The prices for teak at Government depots are rising every year. We may promise the delivery of timber of Quality III C. The girth of such timber would be between 76-99 cm. We may promise to supply timber as far as possible of girth on the higher side between this and the girth limit. The prevailing depot price of III C timber is approximately Rs. 16,000/m^3. Adding 5% Forest Development Tax and Income Tax 5% and Sales Tax 8%, it comes to Rs. 18,880 or nearly 19,000/-.

The market price is much higher than the depot price. We can, hence, for computation purpose, fix the cost of one m^3 of timber of Quality III C as Rs. 20,000/-.

Scheme : Teak Unit Bonds

(a) The Banks double the money in 5½ years (Indira Vikas Patra) and money becomes 4 times in 11 years.

In order to make our scheme more lucrative, we may realise the price of 0.5 m^3 of timber for one Teak Unit Bond and supply 1 m^3 after 5 years in the first scheme and 2 m^3 after 10 years in the second scheme. Hence as per above cost data, each unit bond will cost Rs. 10,000/- i.e. the cost of 0.5 m^3 of Teak which we have calculated for computation purpose.

(b) Teak prices have increased nearly 10 times in the last 10 years. So we can safely assume that in the next 5 years it will double and in another 5 years still double again. Therefore, the net return on these investment will huge. The net return after 10 years will be nearly 16 times in any case. The response from the public, and concerns will be a frenzy.

No. of Bonds/ha. From 40 year old plantation in the next 10 years we can promise 60 m^3 of Teak as per above discussion. Hence we can fix 30 bonds/ha to such plantations.

Revenue Projection

(a) With 10 year gestation period from 40 year old plantation revenue/ha = No. of Bonds x Value of Each Bond = 30 x 10,000 = Rs 3 Lakhs/ha.

If we take 500 ha of plantations in each of Northern, Central and Southern Circles, the total revenue that can be tapped is 1500 x 3 lakhs = Rs. 45 crores.

(b) From 45 year old plantation also we can get Rs. 45 crores per year.

Total Revenue/Year = Rs. 90 crores/year.

(c) Kerala has over 75,000 ha of Teak plantation. By gradually bringing more plantations under this scheme on a rotation basis every year, Rs. 100 crores can be netted.

(d) By declaring Teak as agricultural crop, income tax concessions could be applied to this scheme. Hence we may properly publicise this scheme and get about Rs. 100

crores of foreign currency by giving NRI Investments priority in allotment.

Quality of Teak to be supplied as per bonds

The quality of timber will be III C type which will have girth on the higher side i.e. (between 76 cm to 99 cm).

Infrastructure

One CCF, three CF, six Dy. CFs and adequate No. of A.C.F.s and subordinate field and office staff along with computer facilities are needed. All this should be put under one Prl. C.C.Fs, who should be here for full time.

Expenditure

A portion of the revenue say 10% can be earmarked for meeting the expense of maintainance of these plantations under this scheme. A small portion of this will be sufficient for infrastructural expenses and expense towards computerisation, etc.

Causes of Loss of Increment

The increment in trees or plantations are lost chiefly because of :

(a) (i). Diseases
  (ii) Fire
  (iii) Loranthus, climbers, etc. (Parasites)
  (iv) Theft
  (v) Biotic interference as uprooting by elephants, and damage by human beings who enter forests for firewood, etc.

(b) As years of plantations increases, No. of standing trees decrease because of drying, uprooting, theft, etc. This is clear from the data sheet also.

Even if this is checked, the increment received by way of growth would be many times more than what is proposed to be sold to public.

The plantations should be maintained statutorily every year with these funds so that the loss in increment is minimised.

Cost to Government

There is no liability even for a single paisa as the Government does not have to spend anything. On the other hand, because of more growth, and hence greater increment than what the trees would have put in normal course, even after reducing the quantity for public from the increment, Government will get much more revenue when the plantations are felled. This is over and above the present immediate revenues.

The exact No. of unit bonds per ha can be decided after field inspection of the earmarked areas by a committee of senior forest officials constituted by the Government.

Action Expected

To begin with, we may start with 500 ha at Nilambur and 500 ha at Konni only to watch the response. We may select site Quality I i.e. very good Teak areas. We can take 40 years and 45 years old plantations each of 250 ha in Nilambur and Konni. Because of very good soil condition for Teak, hence we may take 40 Teak unit bonds/ha for supplying III C quality of timber. Target of immediate revenue expected now itself will be 40 x 10,000 x 1,000 = Rs. 40 crores. In subsequent years, we may revise our rates and targets depending on various factors.

SUMMARY

The commercial management of teak plantations and its financial aspects are given in detail in this paper.

टैक्टोना ग्रांडिस - विशिष्ट प्रबन्ध

आर० एस० आर० प्रसाद

सारांश

इस अभिपत्र में सागौन रोपवनों के व्यापारिक प्रबन्ध और इसके वित्तीय पक्षों को बताया गया है ।

Snippets PLANT LOCATION

A computer programme has been developed that selects optimal OSB plant location and size based on cost minimization. The program, OSB/LOCATION, has two features that make it different from other optimal-location programs. First, the solution is the optimal combination of plant location and size. Second, the program can provide the best alternative solutions in addition to the optimal solutions (or multiple solutions). Alternative solutions provide the decision maker with more flexibility when other factors, such as community life quality and political preference, have to be considered. With small modifications, this program can be used for planning other forest product manufacturing facilities such as laminated veneer lumber plants, or sawmills. For further information, contact Ken J. Muehlenfeld, Forest Products Development Center, School of Forestry, Auburn Univ., Auburn, AL 36849-5418 (USA).

Source : *Forest Products Journal* Vol. 45, No. 5

TEAK - HOW FAST CAN IT GROW AND HOW MUCH CAN IT PAY?

S. PARAMESWARAPPA*

Introduction

Teak (*Tectona grandis*) is one of the most ideal timber trees. The famous Burma Teak has almost become another name for the best quality timber found in the world. Burma and the Western Coast of India during the last century became centres of attraction for British Supremacy, also because of the teak. It is said that during the time of Shivaji, propagation of teak was encouraged. In Karnataka during the time of the Maharaja of Mysore seedlings of teak and other species were distributed.

Distribution

The distribution of teak is largely determined by climate, geology and soil. Teak occurs naturally in portions of India, Burma, Laos, Indonesia (mainly Java) and Thailand. Teak was probably introduced in Java by Indian colonists in the 7th Century A.D. In the Philippines, Teak was also probably introduced. But it has been growing there for a long time. Teak has also been introduced in countries like Sri Lanka, Malaysia, Bangladesh, Pakistan, Indonesia, Zambia, Tanzania, Uganda, Ivory Coast, Ghana, Togo, Nigeria, West Indies, Honduras and Panama.

It was reported from Thailand that the world's largest tree measured 6.71 m in diameter and 46 m in height.

Timber

The sapwood of teak is white to pale yellowish brown and heartwood is pale brown to dark golden yellow. Teak from Burma has chocolate brown colour and that from Thailand is greenish brown and almost black. Teak from India generally is light to dark brown. Teak earned world wide reputation as one of the excellent timbers for shipbuilding. The timber has matchless combination of qualities of resistance to termite, fungus and weather, lightness with the strength, attractive grains, workability and seasoning capacity without splitting, cracking, warping or materially altering shape.

Plantation of Teak and its Growth

Chatu Menon of Malabar in Kerala is called the father of Indian Teak Plantations. Between 1842 and 1862 he raised more than a million well growing teak plants. The first plantation in Karnataka was established at Sakrebyle on the bank of river Tunga, in Gerusoppa and at Kadra in Uttara Kannada and also in Coorg, somewhere around 1852-1860.

Teak develops best on well drained fertile soils. In the Nilambur Valley of Kerala, there are some of the best alluvial pockets in India are still the best sites for teak. The primary factors for growth are drainage and soil depth.

---

* Principal Chief Conservator of Forests, Karnataka.

The fastest growth recorded in teak plantation in the world is from Chittagong District (Bangladesh) at Kaptai. Trees of 21 years age had average height of 29.3 m and average diameter of 30.0 cm; the stem timber volume was 34.09 m^3 and small timber volume was 8.86 m^3 per acre. In this place the teak grows faster than Nilambur first quality teak in general and carries higher volume per acre.

The highest growth under plantation condition in India was seen in the Indo-Gangetic belt of Haldwani Division. At 20 years of age the height growth was 23.1 m and diameter was 28.7 cm. From the general yield table in the first quality teak at 20 years of age, the average diameter is 27.2 cm and average height is 23.2 m. The number of trees per acre is 102. The total yield of stem timber is 28.04 m^3; that means on an average a tree on first quality site at 20 years of age under natural conditions of growth will yield around 0.283 m^3 of timber on good sites.

Analysis of rate of growth

It is said that plantation teak grows slowly after an age of 15 years and besides the strength is not as good as in case of naturally grown teak. .The slowing down of the rate of growth has also been observed in Burma.

It is generally seen that the effect of irrigation and fertilizer application in most tree species is very fast initially and thereafter it slows down. Therefore the initial response of fast growth which is being seen in the young plantation will not hold on for a long time. Secondly under natural conditions the best growth has been seen on alluvial sites where the soils are very deep and moist, but not wet (Teak is very sensitive to poor drainage). It is really difficult to find large areas of alluvial formation in Southern India, therefore the present planting is being done in areas with heavy soils.

The initial fast rate of growth being obtained with fertiliser application and irrigation is bound to come down considerably after few years. There is need for caution about the over optimism regarding predicted high yields from teak plantations. At the best we may expect a tree to produce a maximum of 0.60 m^3 of timber in 20 years under best conditions of intensive management and there could be a maximum of 100 trees per acre.

Of late several commercial companies are floated and they are inviting investment by promising exorbitant returns. As regards the promises made by these companies on financial returns. I have a feeling that they are making exorbitant promises. However, as biological growth has its own limitations, we cannot expect to produce more than 0.60 m^3 of timber per tree at the end of 20 years. It may be possible to pay a sum of Rs. 50,000 to Rs. 1,00,000 depending on the price of teak then obtainable. Looking to the price of teak escalating from Rs. 700 to Rs. 50,000 in a course of 35 years (1960 to 1995) it may touch upto Rs. 85,000/- or Rs. 1,75,000/- per m^3 in another 20 years, which would provide a total income of Rs. 50,000/- to Rs. 1,00,000/-. Apart from this, these Teak Companies will also utilise the deposits made by the depositors in other profitable ventures which should be able to make profits, from out of which, they should be able to offer some returns to the investors.

They will also get some interim revenue from thinning of teak plantations in the 10th and 15th year. Hence, it is necessary to separate the wood from the money, and the wood will be about 0.60 m^3 and the money returns could be anything.

SUMMARY

The growth and yield of teak have been discussed in detail.

सागौन - कितनी तेजी से बढ़ सकता और कितना लाभ दे सकता है ?

एस० परमेश्वरप्पा

सारांश

सागौन की वृद्धि और प्राप्ति का विस्तार से विवेचन किया गया है ।

TECHNICAL AND FINANCIAL EVALUATION OF GREEN EQUITIES

G.A. KINHAL*

Introduction

Forestry in India as a private venture is in its infancy and as a land-use is at its crossroads. After the advent of scientific forestry in the nineteenth century, there have been a number of occasions when this sector has made an attempt to change the pattern of Forest Management.

Briefly, it could be said that forest has moved from diffused (ownership-wise), unmanaged and unlimited resource-status to a fully owned (Govt. ownership), unitarily managed (Forest Dept.) and very scarce resource-status in the last century. In India, the constraints, such as unalterable (with no substitutes) dependence, vastness of the resource and poverty, have forced the forestry sector to change itself in a different direction in the last two decades than it was in the earlier decades of this century. All attempts of the Government to conserve this resource appear to have isolated the resource from the people as far as their responsibility towards maintenance and development of the resource is concerned while their dependency and inbuilt pressures on the resource have on the contrary increased due to population explosion and advancement in the use technology.

Productivity of India's Forests

India has a land area of 38.50 million ha under good forest cover. Although located in the tropics, the productivity of India's forests is amongst the lowest in the world. The current productivity is only 0.7 m^3/ha/yr. At the present levels of consumption of forest resources, the country needs a minimum of 0.47 ha of forest land for every individual against the actual availability of 0.11 ha. The figure of productivity on the basis of recorded productions is only 0.5 m^3/ha/yr (Lal, 1986).

The actual productivity assessed by the Forest Survey of India in well managed and reasonably protected forests in different regions of the country is as given in Table 1.

Table 1

Productivity of forests

Region	Productivity (m^3/ha/yr)
Western Himalayas	2.21
Eastern Himalayas	2.03
North East	1.66
Western Coast and Andaman & Nicobar Islands.	3.85
Deccan	1.35
Central India	1.05
Gangetic	0.86
Dry forests of Indus plain	0.41

These figures do not indicate average productivity but that of those forests which are more or less free from adverse biotic interference. That is, these represent potential productivity for most of the forests of the country. The field assessment gives the figures of average potential productivity only at about 1.5 m^3/ha/yr.

---

* Faculty in Technical Forestry and Ecosystem Management, Indian Institute of Forest Management, Bhopal (Madhya Pradesh)

Under the above described conditions, it could be seen that the pattern of change in the forest management in the last decade has been from "single department" affair to a state of multidimensional activity involving people at various decision making levels. The present day forester talks of involving people, in and around forests, in the protection and management of forests. Another such development is the development of the corporate sector in the forestry development. Although this is mostly to cater to the needs of the industries, it would also add to the quantum of forest products available to the people at large. There have been some attempts to raise captive plantations to augment raw materials for industries.

There are three variations in the corporate sector forestry, they are :

(i) Captive plantations on the land owned by the company with own investment (WIMCO Ltd).

(ii) Captive plantations on farmers fields with own as well as borrowed funds. (WIMCO Ltd).

(iii) Plantations on own land with funds raised from the market by way of shares/ equities/debentures etc.

The third aspect is the purview of this paper.

Review of Literature

As already stated, forestry as a private venture is in its infancy. That is why there is paucity of precise literature on this aspect of forestry. The process of tree planting, rearing and harvesting is yet to be considered a serious enterprise and is not adequately supported by economic analysis of costs, constraints, returns and identification of public policy options (Joseph, 1992). In spite of the thrust accorded to growing trees both on government and private lands in the last decade this sector has yet to show its penetration into the economy to the extent that it caters to the various needs of the people. Due to lack of such development, both in government as well as private ventures, the greening of the country as a "motto" has not yet picked up. Although, most of the states have implemented various patterns of social forestry projects, the anticipated impact has not been noticed. Still such stray examples like WIMCO etc. help to indicate the possibility and keep the interest in this field alive. But the kind of offers/schemes that are being floated with an assurance of high returns on small investments make detailed study of such offers necessary.

There are various permutations and combinations of these offers with land and trees, different extent of land on which trees are grown and number of trees grown linked with gold bonds, Indira Vikas Patras, holding recreation facilities in plantation sites, discontinuance and compensation, personal accident insurance coverage (not for trees) and incentives. The assurances of the agencies are that they will raise trees by scientific methods employing experienced professionals, the trees will be insured and one can always take back the money or transfer the membership to any other person (Joseph, 1992).

It is true that the spiraling prices of

teak and the present day attractive returns have caught the imagination of investors, they are ignorant about the fact that the assumptions and estimations of these companies need a technical back up. Mr. Joseph further says, the industry, whether in the corporate or cooperative sector must be encouraged to take farmers as partners in such enterprises, but the predictions and commitments made should be nearer to achievable figures.

According to forest officials, a couple of such attempts done in South India were unsuccessful. They claim that a teak tree, which takes about 70 to 100 years to mature cannot give a return of Rs. 1,00,000 in 20 years. They cannot get Rs. 100,000 for a teak tree after 20 years because it will still be a pole not a full grown tree (Prasad, 1993). The project of growing teak trees under controlled conditions has never been tried anywhere in the country as a commercial venture. The quality of timber expected from teak trees grown under high intensity management would not be as good as the trees growing in a natural habitat (Prasad, 1993). While the companies claim that it is possible to expedite the growth of teak with proper care, fertilizer and irrigation, the forest officials' technical argument is that, the rings in the trunk will be shorter and the grains will not be as good as a mature tree. The quality will be poor and a large portion of the trunk will have the sapwood (not useful as timber).

Some data for the Teak plantation efforts are available from Kerala State. Only the details regarding the post plantation establishment operations are being considered for analysing the yield potential of teak under different site quality conditions.

(a) *Post establishment operations in teak plantations* : The post establishment operations commence in the 4th year (some places it is the 6th year) when the first thinning is carried out and thinning is repeated in the 8th, 13th, 20th and 44th years. The first two are systematic (or mechanical) and reduce the crop from 2500/ha at the time of planting to 1250/ha at the first thinning and to 625/ha at the second. All subsequent thinnings are selective and are aimed at producing an even distribution of the crop. Thinnings are carried out with reference to the All India Yield Tables and the general 'rule of thumb' is that the spacing should be about 1/3 of the average height. Table 2 gives details of the thinning yields obtained from plantation in the Konni Forest Division, Kerala.

Table 2

Thinning yields obtained from teak plantation in the Konni Forest Division (Kerala).

Age (years)	Yield (m³/ha)		
	Poles	Timber	Total Vol.
4	0.439	-	0.439
8	2.646	-	2.646
13	4.381	0.005	4.386
20	6.865	0.180	7.045
30	7.328	1.591	8.919
44	7.808	4.610	12.418
Total	29.467	6.386	35.853

(b) *Final fellings and yields in teak plantations* : In the Konni Forest Division, the rotation adopted is 70 years and is aimed at obtaining of trees of over 180 cm girth although it is only in Site Quality Class-I that the maximum number of trees of this size is obtained. Table 3 gives the details.

Table 3

Crop diameter (cm) and percentage of trees above the exploitable diameter of 57.3 cm (180 cm girth).

Age	Site Quality			
(Yrs.)	I	II	III	IV
50	55.4	39.9	26.4	17.0
	(36)	(2)	(0)	(0)
60	60.7	45.0	30.0	19.0
	(59)	(4)	(0)	(0)
70	65.3	49.3	33.3	20.8
	(80)	(8)	(0)	(0)
80	69.0	53.5	36.8	22.9
	(88)	(25)	(0)	(0)

Figures in parentheses represent the % of stems above exploitable diameter.

Based on total volume, the age of maximum volume production varies from 5 to 15 years depending upon the site quality. Taking stem wood volume alone, the mean annual increment culminates at age 50 years on Class-I sites and age 75 years on Class-II sites. The average yield from final fellings in Konni plantations was 88.86 m^3/ha of timber and 47.79 m^3/ha of billets. The total yield obtained from thinnings and final fellings averaged to 172.32 m^3/ha on a rotation of 70 years which gives a mean annual volume of 2.46 m^3/ha.

Green Gold Gimmicks

A new phenomenon to promote various timber species (especially teak) with small investments from general public in the form of contributions towards one or more trees to be planted in a chunk of land owned by the sponsorers has recently emerged in India.

Teak (*Tectona grandis*) is the main species in these proposals. Its value and suitability for a wide range of uses, because of its freedom from serious problems related to disease of pests and because, establishment and maintenance techniques are simple and investment requirement relatively low. Teak is a very good coppicer and is a very hardy species suitable to be planted on a variety of soils.

While rosewood, banana, mango, silver oak, coconut also form part of these proposals they invariably call teak as green gold.

Location of Land : In all the proposals the land is located near big cities like Madras, Bangalore, Bhopal, Dehra Dun etc. This is probably with an eye on the future market and also presently these places being suitable to the companies.

Allocation of land / tree : The allocation of land per tree (final stage) varies from 9.29 m^2 to 10.68 m^2.

Investment pattern : Most of the proposals have a pattern of one time investment per tree. The per tree investment varies from Rs. 495 to Rs. 2,500.

A Company has a variety of offers in which the investment per tree is of Rs.1,275. One can invest on 2, 5, 8, 11, 16 and 21 trees. They also have an assurance of allotment of about 10.70 m^2 land per tree, in the name of investor. Some of these offers provide for payments in instalments also.

Gestation period : The gestation period varies from 11 years to 20 years for teak and other species.

Growth rate and return : The growth rate estimated varies from 0.050 m^3/tree/yr to 0.056 m^3/tree/yr. At the end of the project period of 20 years, each teak tree is expected to give 1.13 m^3 of sawn timber. These schemes assume a return of Rs. 90,000 per m^3 after twenty years. A Company has also come out with a "Retirement Teakquity" scheme in which an investor can opt for a monthly return of Rs. 620/- per tree after twenty years.

Technical and Financial Analysis

As there are no growth data available for teak grown under controlled conditions as a commercial venture, we may have to resort to comparing the estimations and assumptions made in these green equities with the available data on teak plantations raised by the forest departments on forest lands.

Similarly the financial analysis would rest on the price changes in teak-timber prices in the sales organised by the Forest Departments through their sale-depots. On this aspect also the price data are not easily available.

Technical Analysis : In the Konni Forest Division, Kerala, the annual volume yield attained on a rotation of 70 years was 2.46 m^3/ha. If we assume that after all the thinnings were completed, there would be on as average 300 trees/ha, then the mean annual volume attained per tree works out to 0.0082 m^3. In these schemes, the mean annual increment per tree assumed is about 0.054 m^3 which is approximately 7 times the actual attained, that too in 20 years period (approximately one-fourth). Another critical factor is that the yield assumed is in terms of sawn timber, while the yield obtained in Konni Division is in round volume. Even if we assume a conversion factor of 0.70 from round to sawn timber the assumed annual increment per tree rises to 0.077 m^3 approximately 10 times the actual attained. This quantum of yield at the age of 20 years appears technically infeasible.

Financial Analysis : The available domestic teak prices (Table 4 indicates that in Andhra Pradesh the price/m^3 increased from Rs.459 in 1967 to Rs. 920 in 1976 i.e. double in 10 years. In Gujarat State price per m^3 has increased from Rs. 1208 in 1979 to Rs. 3300/m^3 in 1982 i.e. a 2.7 times increase in four years. The present prevailing average price in the country is around Rs. 12,000/m^3 for round timber. Thus the price assumption of Rs. 56,000 to Rs. 87,500/m^3 for sawn timber after 15-20 years of the project period appears to be on the higher side, especially when the trade monopoly of the Forest Department is going to be broken. The prices

Table 4

Forest Products Prices- Domestic Teak Prices.

Size of the Timber		Years									
		1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
90 to 120 cm girth	Rs./m^3	459	455	416	455	490	530	525	770	875	920
Andhra Pradesh	US \$/m^3	61.23	59.95	55.34	60.67	65.66	69.79	67.81	45.04	100.02	102.7
					1979		1980		1981		1982
60-90 cm girth	Rs./m^3				1208		1380		2095		3300
Gujarat	US \$/ m^3				148.7		175.5		241.9		349
120- 150 cm girth	Rs./,^{3}				1635		1965		2360		4100
Gujarat	US \$/m^3				201.2		250.3		272.5		433.40

may not escalate to that extent as the quantity of timber available in the market is likely to increase because of such schemes.

Conclusions

The proposals/offers of the different green equities are heavily lopsided with little technical and financial feasibility. Apart from above factors, these schemes also have following subjective inconsistencies :

1. The tree certificates issued to the investors are transferable and can be bought and sold. But the fact that these certificates will not be quoted in the stock market and the gestation period is long would make it difficult for the investors to find buyers.
2. The quality of timber extracted from teak trees grown under high intensity management would not be as good as the trees growing in a natural habitat.
3. At the age of 15-20 years a large portion of the trunk of the tree will have the sapwood.
4. In case of natural calamities like fire, floods, drought and insect attack, there is no guarantee against the loss.
5. The assumption that income from these schemes would be a tax free income even after 20 years period may not be correct under the present changing financial and economic scenario in the country.
6. Substitutes to teak wood may be developed in a period of 20 years.

Epilogue

Although Green equity schemes are of immense importance in terms of involvement of private people in the forestry sector, it would be proper to remodel them according to technical and financial feasibilities. Apart from the Forest Policy objective of greening 1/3rd of the country's land mass the ever widening gap between demand and supply of timber, fuelwood, pulpwood and other tree based raw materials force the government to encourage adoption of imaginative policies and bold initiatives to involve all possible agencies and individuals in a massive tree planting effort based on contemporary scientific knowledge and sound management practices. The government must encourage such investments by offerng incentives in the form of subsidised lending, disaster insurance, tax exemptions etc. This would help not only to fulfil the forest policy mandates but also provides enough stimulus to transform the rural landscape of India.

SUMMARY

Forestry in India as a private venture is in its infancy and as a land use at its crossroads. The scientific forest management in this country is approximately 100 years old and during this period, it has seen and experienced various jolts. Forest - as a resource of environmental and economic importance - has moved from diffused (ownership wise), unmanaged and unlimited resource-status to a fully owned (Government ownership), unitarily managed (Forest Department) and very scare resource-status. Present day upsurge in environmental awareness and the role of forests in environmental conservation has enhanced the importance of this sector to such an extent that people from various walks of life give innovative ideas of management for this resource. This paper concentrates on the upcoming corporate sector in plantation forestry by way of either company investment or investment from public. An analysis of such proposals presently being floated by various companies has been done in terms of technical feasibility and financial viability vis-a-vis the experience of the Forest Department in raising Teak (*Tectona grandis*) plantations. While this paper assesses the proposals to be based on unattainable assumptions, it also suggests the governments to encourage such attempts by giving subsidies/incentives.

हरे साम्यों का प्राविधिक और वित्तीय मूल्यांकन

जी०ए० किन्हाल

सारांश

भारतवर्ष में निजी उद्यम के रूप में वानिकी अपने शैशवकाल में तथा भूमि उपयोग के रूप में चौराहे पर खड़ी है । वनों का इस देश में वैज्ञानिक प्रबन्ध अब लगभग एक शताब्दी का हो चला है और इस अवधि के दौरान इसने बहुत कुछ देखा और सहा-झेला है । पर्यावरण में और आर्थिक महत्व के रूप में वन प्रसृत (स्वामित्व के विचार से), अप्रबंधित और असीमित स्रोतों वाली स्थिति से चलकर पूरे स्वामित्व वाले (सहकारी स्वामित्व) एक जगह से प्रबंधित (वन विभाग द्वारा) और बहुत कम स्रोत वाली स्थिति तक आ गए हैं । पर्यावरण जागरूकता के वर्तमान उछाल और पर्यावरण संरक्षण में वनों की भूमिका ने इस क्षेत्र का महत्व इतना अधिक बढ़ा दिया है कि जीवन के विभिन्न क्षेत्रों में कार्य करने वाले लोगों ने इस स्रोत का प्रबन्ध करने के बारे में नये-नये विचार प्रस्तुत किये हैं । इस अभिपत्र में रोपवन वानिकी में कम्पनियों द्वारा धन लगाने अथवा सार्वजनिक धन लगाया जाने के परिणाम स्वरूप उभर कर आ रहे सामुदायिक क्षेत्र पर ध्यान केन्द्रित किया गया है । अभिपत्र में विभिन्न कम्पनियों द्वारा शुरू कराए जा रहे इस तरह के प्रस्तावों का विश्लेषण उनकी प्राविधिक शक्यता तथा सागौन (*टैक्टोना ग्रांडिस*) के रोपवन तैयार कराने में वन विभाग को प्राप्त हुए अनुभवों की दृष्टि से उनकी वित्तीय संभाव्यता की दृष्टि से किया गया है । यह अभिपत्र इन प्रस्तावों को यद्यपि प्राप्त न हो सकने वाली अभिधारणाओं पर आधारित किया हुआ अनुमानता है, फिर भी इसका सुझाव है कि सहायता एवं प्रोत्साहन देकर सरकार को ऐसे प्रयत्नों को बढ़ावा देना चाहिए ।

References

Anon. (1988). Forest products prices - *FAO. Bulletin* **82**.

Anon. (1970). *Growth and yield statistics of common India Timbers*, Vol-II, FRI, Dehra Dun.

Anon. (1987). *Reports on field inventories and vegetation mapping,* F.S.I.

Joseph, S.J. (1992). Investors in Teak Cautioned. *The Hindu Survey of Indian Agriculture*. pp. 187-191.

Lal, J.B. (1986). India's Forests - Myth and Reality. *Natraj Publishers, Dehra Dun.*

Prasad, R.R. (1993). *"Own your Tree" schemes floated* The Times of India (May 16).

THE BOUNTY FROM THE TEAK TREE

C. JAGANNATH REDDY *

Introduction

Only quite lately, numerous newspapers have been carrying advertisements claiming, inter alia, that Rs. 1000 invested on a teak tree grows to Rs. 50,000 over a period of 20 years. This means the timber yielded by the tree would be worth that much.

As much as 112 m^3 of quality timber is obtainable from a single teak tree. Such solitary specimens are met with in the vicinity of interstate borders of Kerala and Tamil Nadu as also in Burma. So huge and wide is the girth of the trunk that it needs at least five people to encircle it by stretching their both hands horizontally along the periphery of the circumference. The height is so much that one has to go 90 m from the base of the tree to photograph its full length. To transport the overground biomass, it needs a minimum of 10 lorries, each of 10 tonnes capacity.

However, in parts of Andhra Pradesh, trees with a girth upto 3.65 m were not uncommon, each of them yielding upto 11.2 m^3. Trees with a yield of 1.12 m^3 each, growing on black alluvial soil abutting the banks of the Godavari, were common. As of today, it is difficult to find a tree attaining 0.30 m^3 of timber before it is felled by a miscreant. However, the growth potential is so much that its coppice shoots in Burma attain as much as 32.5 cm basal girth in a matter of just two years, (Forest Flora of Hyderabad State) and that, a tree of seedling origin attained 19.77 m height and 1.97 m girth at breast height, yielding about 2.80 m^3 of timber in a matter of 28 years, in reverain alluvial soils in Mysore District.

Widespread Impression

Forest lands are so degraded that one has to wait for 60 to 80 long years before teak trees attain respectable dimension and become fit for utilization. So widespread is the impression that per unit time and per unit area production does not justify the growing of teak on commercial lines. The impression may be relevant in so far as growth of forest teak is concerned. Now there are, commercially speaking, three distinct teak trees, forest grown teak, forest plantation grown teak and orchard teak. Orchard teak grows six times faster than forest grown teak and twice as much as forest plantation well-grown teak. The forest conditions that once existed for quick growth of teak are no longer there. But in optimum conditions, teak demonstrates higher growth potential and affords quality timber in a record time. The forest plantations teak though not well-tended, had registered three times more growth than forest grown teak.

---

* Horticulturist, Hyderabad (Andhra Pradesh).

Gamble, a world-renowned forester, had studied very extensively the growth rates of teak in different regions including Burma. On a transverse section of a teak stem grown under plantation conditions, Gamble found four annual growth rings per inch of radius as against an average of twelve annual growth rings on a transverse section of a forest teak stem. This growth pattern is mentioned in 'Forest Flora of Hyderabad State'. It is thus proved that a plantation teak grows three times faster than forest teak of the same age.

More Aeration

In orchard teak soils, more aeration is ensured by constant mechanical interculture of loosening the ground keeping the soil more friable. The more the aeration, the better would be the supply of oxygen to the root system which makes all the difference in growth potential. Loosening of the soil means that a larger supply of oxygen is admitted to the roots. The reason why water-logged ground is unsuitable is that the roots are seriously deprived of oxygen, leading to the death of plant or growth retardation. Prof. H.G. Champion in his manual "General Silviculture for India" endorsed that the initial height growth 'may even be doubled' by aeration.

Aeration followed by irrigation, repeated as and when required under orchard conditions during non-rainy season, particularly summer months, accelerates the growth rate of teak. It is generally understood that forest teak grows (if not in summer due to moisture stress) at least during the rainy season. Immediately after a downpour, soil beneath the trees forms into crust - a phenomenon known as crust formation, which impedes aeration resulting in the stagnation of growth of teak even during the rainy season. The deep leaf litter that existed in the erstwhile forests is no longer there to offset the ill-effects of the downpour. The forest plantation areas are practically devoid of leaf litter due to seasonal fires and the resultant crust formation following heavy downpour retards the growth of teak. Pests too denude the trees of leaves, thus arresting the seasonal growth.

Growth Rates

Growth rates of teak in Uttar Pradesh are also very impressive. Shri Kadambi in his book "Silviculture of Teak" mentions one plantation 21 years old in Haldwani Division having attained 34.5 cm diameter and 25.9 m height. In Baster of Madhya Pradesh one plantation 24 years old acquired a diameter growth of 38 cm at breast height equivalent to 1.22 m girth - really an appreciable growth. Even in Andhra Pradesh but outside natural zone of teak in the districts of Visakhapatnam and East Godavari, teak is found growing very impressively. An eleven-year-old plantation in Rajaomangi Reserve Forest as recorded by Sharfuddin Khan in his booklet "Teak in A.P." has put up 72.5 cm girth and 12.46 m height. If plantations are raised at this scale of growth rates, no crop, agricultural or horticultural, coffee or tea, is as remunerative as teak. One more plantation in Rajaomangi Reserve Forest aged just 13 years, produced an equally outstanding growth rate of 77.5 cm girth and 14 m of height. By A.P. Forest Department standards, these growth rates of teak are substantial.

The teak plantation raised over 20 years past in Thanjavur delta in Tamil Nadu, over an extent of 2100 hectares are worth Rs. 400 crores as evaluated by Shri

Khondas former Principal Chief Conservator of Forests, who had further stated that 20-year-old trees had each produced 1 m^3 of wood. A very fantastic growth indeed.

The photographs by R.S. Troup in his book "Silviculture of Indian Trees" of 9 years old plantation in Burma and of 14 years old plantation in Kerala are illustrative of growth potential of teak. Such plantations are capable of yielding good timber after 20 years of age.

The growth rates of teak in other continents such as Africa are even better. Teak in Dahomey attained an abnormal growth rate of 42 cm girth in four years of its life while in Togo and South Africa, the growth rates in Site Quality IV areas compared with those of Site Quality I in India (FAO Publication on Teak, 1956).

Wood Quality

There are other apprehensions as to the quality of wood grown in the shortest time possible. Forest grown timber with 1 to 4 annual growth rings per 2.54 cm of radius from Government-raised plantations were tested at the Forest Research Institute Dehra Dun. The timber was found to be in no way inferior to that grown in natural forest conditions with 12 annual rings per 2.54 cm of radius. In the tests it was found that it was only the weight per unit volume but not the growth, faster or slower, per unit time which matters in the strength properties of the timber. In irrigated and fertilized conditions, timber gains more weight. Field crops too provide best examples. Their per unit volume biomass is more weighty than that grown in unfertilized and unirrigated areas.

The apprehensions about growth potential of teak, therefore, are not well-founded. Of the profitability of tree farming, farmers notably the Patels of Gujarat State provide the best example. They made a higher profit than they would have from crops like wheat and cotton. They had shown what could be done successfully in a short time. What is required is to repeat such work by combining the available technology with the best management.

SUMMARY

Planting of teak under irrigated condition yields more timber than unirrigated condition in 20 years.

सागौन वृक्षों के उपकार

सी० जगन्नाथ रेड्डी

सारांश

असिंचित दशाओं में लगाने की तुलना में सिंचित दशाओं में सागौन को लगाने से 20 वर्षों में उससे काफी अधिक प्रकाष्ठ प्राप्त होता है ।

RESEARCH NOTES

(I)

MORTALITY IN PURE TEAK PLANTATION

The Teak (*Tectona grandis*) plantations are being raised in forest areas of Maharashtra, since long. However with the establishment of Forest Development Board (FDB) in 1969, systematic teak plantation works started on large scale. Later on in 1974 FDB was replaced by Forest Development Corporation of Maharashtra (FDCM Ltd.). Main objective of FDCM Ltd. was to convert "Potentially Productive Forests" into "productive forest" by pure teak plantation.

Some of the oldest plantations carried out by FDB in Maharashtra were visited during the course of inventory. In one of the 1970 teak plantation (24 year old) in Saleghat Range (Compt. No. 655) of Nagpur Forest Project Division large scale mortality was observed. On careful observation it was evident that mortality occurs mostly in girth class below 45 cm. There is almost no mortality in girth above 50 cm. Table 1 shows the mortality in various girth class per hectare. It is also observed that mortality is spreading because many trees are found in different stages of dying process.

In past mortality in natural teak or in coppice teak was reported by various authors (Anon., 1953; Anon., 1954; Bakshi *et al.*, 1972). The mortality of teak trees observed was tentatively attributed to drought or severe damage to the bark caused by the termite (*Odontotermes parvidens*). In the above mentioned plantation severe damage of the bark by termite was observed. Damage by termite was observed even in dying trees. Roots of some of the dead trees were examined after uprooting the tree, reveals no insect or fungus attack on root system. In many cases the coppice shoots from the ground level was observed after death of tree. Hence it can be safely concluded that root damage is not the cause of mortality.

Table 1

Mortality in teak plantation/hectare.
Age of Plantation - 24 years.

Girth Class	No. of Dead trees	No. of (cm) Dying trees
16-20	12	4
21-25	16	-
26-30	28	4
31-35	24	-
36-40	20	8
41-45	12	10
Above 46	4	6
Total	116	32

It is also observed that around 65 to 70% of mortality takes place in plain area with better soil depth. During 1993-94 from 48.12 hectare area 1070 number of dead trees were removed to stop the spreading of mortality. But observation after one year reveals that spreading of mortality continued.

Although exact cause of mortality could not be ascertained this process and spread of mortality is of great concern. It is also learned from the discussion of the local forest staff that some mortality are observed in other plantations also. Above observations on mortality in pure teak plantation needs detailed study. These observations also suggest that teak monoculture should be undertaken only after careful study of the various damaging factors to avoid any large scale mortality in future.

References

Anon. (1953). Mortality of Sal and Teak in Gorakhpur Division, *For. Res. in India,* Part I pp. 75 (E).

Anon. (1954). Mortality of teak in Mandvi Range. *For Res. in India,* Part II pp. 23.

Bakshi, B.K., M.A.R. Reddy, Y.N. Puri and Sujan Singh (1972). Forest Diseases Survey. *Final Technical Report.* Forest Pathology Branch, FRI, Dehradun. pp. 117.

Mohan Jha

Divisional Manager,
Plantation Inventory Unit,
F.D.C.M. Ltd., Nagpur (Maharashtra)

(II)

EVALUATION OF GROWTH RESPONSE OF TEAK TO HIGH INPUTS

In our articles titled "Sewage Water as potential for tree growth - A case study on Teak (*Tectona grandis*) plantations", and "Growth response to irrigation -Eksal (Ambhadi) Teak Plantation - A case Study" (see pages 472-481 and 491-502) a passing reference was made on quality of wood developed in irrigated and high input teak plantations. As the wood samples were not scientifically tested by competent authority for its physical and mechanical properties, the material was described in general terms. Recently timber developed under similar conditions, was sent for testing to Institute of Wood Science and Technology, Bangalore, from whom assessment report is now available, which being of topical interest is discussed here.

M/s. Ichalkaranji Co-operative Spinning Mills has raised a teak plantation in 1986, at Ichalkaranji, District Kolhapur in the Western Maharashtra Dry Zone i.e. Agro-climatic zone VI of Maharashtra. In addition to the normal practices, the plantation receive a regular flood irrigation at an interval of 3 to 4 weeks, during the dry season. As a spinning mill, the firm generates lot of cotton waste/linter, which in effect is bio-degradable and results in increasing humus. The firm used such a material to fertilise the teak plantation. However, quantitative details of such fertilisation are not available.

As a consequence to such high inputs, the plantation has put on good growth, for the average site quality of the area. Close monitoring of this plantation activity has revealed that saplings attained average dimensions of 28.5 cm (G.H.O.B.) and 10.8 m of height, at the age of 7 years. The total basal area was 14.82 m^2 and thus, thinning was carried out in the year 1994. The samples collected from thinned material were supplied to Institute of Wood Science and Technology, Bangalore as indicated in Table 1.

Table 1

Sample No.	Length (m)	Mid girth (cm)	Girth at large end (cm)	Girth at small end (cm)
T1	3.00	25	32	21
T2	3.02	30	36	25
T3	3.00	48	49	38
T4	3.02	37	45	36
T5	3.00	50	62	46

Table 2

Properties	*Tectona grandis**		Standard Teak	
	Green Average	Air-dry Average	Green Average	Air-dry Average
Sp. gravity (based on oven dry weight and volume at test)	0.425	0.479	0.596	0.604
% Moisture content	68%	12%	76.6%	12%
Weight	786	538	1056	672
Static bending				
Fiber stress at elastic limit (kg/cm²)	362	423	509	651
Modulus of rupture (kg/cm²)	605	615	841	959
Modulus of elasticity (X10³ kg/cm²)	76.2	70.6	109.7	119.6
Compression parallel to grain				
Maximum crushing stress (kg/cm²)	211	295	415	532
Compression perpendicular to grain				
Compressive stress at E.L. (kg/cm²)	32.7	104.4	86	101
Hardness (load to embed 1.128 cm dia steel ball to half its diameter)				
Radial (kg)	315	450	557	502
Tangential (kg)	334	550	551	524
End (kg)	459	655	486	488
Shear parallel to grain				
Radial (kg/cm²)	35.1	64.1	89.5	96.6
Tangential (kg/cm²)	47.6	82.6	100.2	108.0
Tension perpendicular to grain				
Radial (kg/cm²)	10.1	36.8	68.3	57.6
Tangential (kg/cm²)	17.3	35.4	79.4	66.4

* Test results based on 4 billets

Table 3

Nail holding power

	Green Average	Air-dry Average
Side	98	52
End	48	20

Table 4

Screw holding power

	Green Average	Air-dry Average
Side	129	121
End	51	52

Table 5

Suitability indices of Tectona grandis in terms of Teak as 100

Properties	Suitability indices
Strength as a beam	69
Stiffness as a beam	65
Suitability as a post	60
Shock resisting ability	62
Shear	53
Refractoriness	31
Hardness	73
Weight or Heaviness	80

Results of various tests carried out at the Institute are tabulated in Tables 2, 3, 4 and 5.

The Head of Wood properties and Uses Division of the Institute, concludes that the timber tested is moderately heavy, weak, not tough and moderately hard. Our apprehensions that indiscriminate high inputs will jeopardise timber quality have been vindicated. It is hoped that this investigation and its result will be kept in view by all those entrepreneurs who are selling "dreams" of high returns.

Conservator of Forests,
Forest Research Circle,
Pune (Maharashtra).

M.G. Gogate

(III)

PEST STATUS AND LARVAL FEEDING PREFERENCE OF *SPODOPTERA LITURA* (FABRICIUS) BOURSIN (LEPIDOPTERA : NOCTUIDAE) ON TEAK

Teak (*Tectona grandis* L.f.) is undoubtedly one of the most important and valuable commercial timber species. This potential tree species has a rich complex of insect fauna and is one of the most extensively studied timber species for its entomology. Teak suffers regularly from insect damage in most of the teak growing areas in the Indian sub-continent. All the stages in the growth of teak from seed to mature trees are attacked by the insects. The damage occurs from an association of group of insects, comprising chiefly defoliators, gall-formers, root-feeders, together with combination of many species of foliage feeders, stem borers, etc. of about 280 and odd species (Mathur, 1960; Mathur and Singh, 1960), which the teak is reportedly supporting, great majority of them are casual visitors, a few of them, however, are source of real menace and concern to the forest managers (Tewari, 1992).

Defoliation is a chronic feature in teak plants and defoliators are the main enemy of teak. About 139 defoliators have so far been recorded on teak which includes 80 Lepidopterans, 41 Coleopterans and 18 Orthopterans (Mathur, 1960); Mathur and Singh, 1960). Among the Lepidopteran defoliators, *Spodoptera litura* (Fabricius) Boursin (syn. *Prodenia litura* Fabricius) (Lepidoptera : Noctuidae) has been reported to feed on teak (Beeson, 1941; Browne, 1968). Surprisingly, enough information is not available regarding its pest status and larval feeding preference on teak. The present study clarifies these aspects unequivocally and the present account is based on the field observations of authors.

To study the insect pests damaging teak seedlings at nursery stage, periodical surveys were carried out at Jabalpur (M.P.), during the year 1993-94. During the course of study, it was observed that teak seedlings suffers seriously from the attack of an insect larvae which was later identified as *S. litura*. This insect is commonly called as tobacco semi-looper (Browne, 1968). This wide spread species is a very general feeder on agricultural and garden crops and a pest particularly of cotton and tobacco (Chari and Patel, 1983). This insect has been recorded to feed on many forest trees and shrubs such as *Artocarpus integra, Casia tora, Casuarina equisetifolia, Diospyros montana, Hevea brasiliensis, Lantana camara, Mangifera indica, Morus alba, Populus* spp.; *Randia dumetorum, R. uliginosa, Solanum indicum, S. torvum, Terminalia tomentosa, Thuja orientalis* and *Tristania conferta* in India and its neighbouring countries (Beeson, 1941; Browne, 1968), and recently also recorded as a pest of *Jatropha curcas* (Meshram and Joshi, 1994) and *Sesbania* spp. (Roychoudhury *et al.*, 1995a).

The present study reveals that eggs are laid in a mass on the under surface of the leaves of intermediate (medium) quality just below the tender leaves. The egg clusters remain covered with ovipositor scales, shed from the tip of the mother's abdomen. The fecundity is very high, which varies from 300-400 eggs in a mass. After nearly 4-5 days of egg period, the hatching takes place. The young larvae feed gregariously and later on disperse. They are voracious feeder, consuming the whole of the leaf surface including the veins. The full grown larvae are dull, olive green coloured with light side stripes, which attain a maximum length of about 35 mm. The pre-pupae are 23-26 mm in length and the prepupal period varies from 1-2 days, The pupation occurs in a loose silken cocoon in soil. The pupae are 14-15 mm in length and the pupal period varies from 5-8 days. The moths are nocturnal and medium sized. The forewings have beautiful golden and grayish brown patches. Hindwings are greyish white in colour.

This insect has been found in abundance only during the month of June-July. About 56% of teak seedlings are recorded to be damaged by this insect pest. To control the population outburst of this insect, Fletcher (1914) has suggested hand picking of egg masses and batches of young larvae before lossing their gregarious habit. Ram *et al.* (1988) recommended foliar spraying of endosulfan 0.08% against the larvae of *S. litura* as effective control measure.

Larval feeding preference

During the present work, it has been recorded that the early larval instar feed on the leaves of intermediate (medium) quality which are in between tender and mature older leaves. The late larval instar prefer mature leaves. These findings show that larvae avoid soft tender leaves which clearly indicate that in *S. litura*, larvae exhibit feeding preference in relation to leaves of different maturity particularly on teak. The results show some parallelism with the findings of earlier workers on the same insect and host plant (Beeson, 1941). This is possible because ubiquitous variation in leaf quality alter the performance of leaf eating insects in all feeding guilds including the palatability (Scriber and Slansky, 1981). Further, leaf allelochemicals may also serve as nutrients or toxins, depending on many factors, including its environment, its concentration, and the physiological state of the receiver (Maiorana, 1979). Recently, unequivocal clarifications have been made on the chemistry of teak leaves of different maturity which revealed that tender leaves contained relatively high percentage of moisture, nitrogen and polyphenol contents followed by a rapid decline in intermediate and mature leaves (Roychoudhury *et al.* 1995 b). The huge concentration of polyphenols in tender leaves is possibly responsible for non-preference by the larvae of *S. litura* because phenolic compounds have antibiotic effects on insects (Singleton and Kratzer, 1969).

References

Beeson, C.F.C. (1941). *The Ecology and Control of Forest Insects of India and Neighbouring Countries*. Vasant Press, Dehra Dun. 1107 pp.

Browne, F.G. (1968). *Pest and Disease of Forest Plantation Trees*. Clarendon Press, Oxford, 1330 pp.

Chari, M.S. and N.G. Patel (1983). Cotton leaf worm, *Spodoptera litura* Fab.: its biology and integrated control measures. *Cotton Development* **13** (7-8) : 1.

Fletcher, T.B. (1914). *Some South Indian Insects and other Animals of Importance.* Govt. Press, Madras, 565 pp.

Maiorana, V.C. (1979). Non-toxic toxins : the energetic of coevolution. *Biol. J. Linn. Soc.* **11** : 387-396.

Mathur, R.N. (1960). Pests of teak and their control. *Indian For. Rec.* **10** : 43-46.

Mathur, R.N. and B. Singh (1960). A list of insect pests of forest plants in India and the adjacent countries. *Indian For. Bull.* **171** (7) : 1-130.

Meshram, P.B. and K.C. Joshi (1994). A new report of *Spodoptera litura* (Fab.) Boursin (Lepidoptera : Noctuidae) as a pest of *Jatropha curcas* Linn. *Indian Forester*, **120** (3) : 273-274.

Ram, S., M.P. Gupta and R.P. Maurya (1988). Efficacy of three insecticides applied in three regimes against insect pest of cow pea. *Indian J. Plant Protection* **16** (1) : 17-20.

Roychoudhury, N., S. Kalia and K.C. Joshi (1995a). *Spodoptera litura* (Fabricius) Boursin (Lepidoptera : Noctuidae), a major pest of *Sesbania* spp. and its species preference. *Indian J. For.* (in press).

Roychoudhury, N., A. Jain and K.C. Joshi (1995b). Alteration of growth and development in leaf skeletonizer, *Eutectona machaeralis* Walker, due to variations in teak leaves of different maturity. *Indian J. Exp. Biol.* **33** (3) : (in press).

Scriber, J.M. and F. Slansky Jr. (1981). The nutritional ecology of immature insects. *Ann. Rev. Entomol.* **26** : 183-211.

Singleton, V.L. and F.H. Kratzer (1969). Toxicity and related activity of phenolic substances of plant origin. *J. Agric. F. Chem.* **17** : 497-510.

Tewari, D.N. (1992). *A Monograph on Teak (Tectona grandis* Linn.f.) International Book Distributors, Dehra Dun, 479 pp.

Forest Entomology Division,
Tropical Forest Research Institute,
Jabalpur (Madhya Pradesh)

N. Roychoudhury
Shamila Kalia
and K.C. Joshi.

FOREST NOTES AND OBSERVATIONS

TEAK PLANTATION

A large number of private and public companies who in the issue highlights of their prospectus are assuring the investors that by investing a very nominal amount on teak trees being raised by them in natural Teak forest regions with latest scientific technologies like raising of seedlings from selected clones in nurseries, adequate watering of plants in plantations with drip irrigation and the like, application of right proportion of fertilizers and pesticides, the prospective investors can earn high returns when their invested trees, felled after 20 years, will have the same quality and marketable value like 60 year old trees from natural teak forests.

From my personal experience, I found that 1953/54 Teak plantations raised from seeds of Assam origin at Pecharthal in North Tripura District excelled in diameter and height growth after 20 years of similar age in A-I site quality of Burmese Teak but the texture, grain, durability, tensile, strength of trees felled after 20 years at Pecharthal for sample plots did not have the same volume or quality of felled trees of older plantations of 60 years and the like at Nilambur or log sawn at Allapalli Saw Mills in the then Central Province during our training in 1948-50.

Admittedly, teak trees raised from selected clones, adequately and scientifically managed can attain significant height and diameter growth at 20 years but can these have the same quality volume and marketable value like 60 year old teak trees, for due to fast growth these would have more porous cells bringing all the natural qualities of strength, durability, texture and grain.

I would, therefore, request our forestry experts and scientists either to dispel the myth or stand by the veracity of the issue highlights of such companies by publishing research papers and furnishing transparent information of their findings.

A.K Ghosh, I.F.S.(Retd)
Ex-Chief Conservator of Forests, Tripura,
Flat No. B/9-6, Purhasa
Calcutta (West Bengal)

From the Indian Forester - One Hundred Years Ago

THE INDIAN FORESTER

June, 1895 (pp. 223-225)

THE QUALITY OF QUICKLY GROWN TEAK-WOOD

Mr. Porter in his article "On the management of Forests producing Teak", printed in your April Number, has called into question the quality of Nilambur Teak, and has virtually challenged the production of evidence to show that the quality of that grown in the plantations is as good as that of Anamalai Teak. Dr. Nisbet has also in his article on "the Diseases of Tree" in the same number, referred to the growth of teak and its attack by fungi on very rich soils. I should like to try and show how it is that, I think they are both, to some extent mistaken.

According to Dr. Nisbet, "Though producing a very much quicker growth of teak, these alluvial plantations can never be expected to furnish supplies of the finest quality of timber, and if the degree of fertility exceeds a certain (indefinite) limit for the given circumstances of soil and situation, then it seems almost certain that there will be predisposition towards disease either in individual stems or as a general characteristics of the whole". This is the theoretical statement which Dr. Nisbet subsequently states is verified by experience, and he gives his example. Now, what does this example prove when carefully examined ? It proves this, that, if to an excessively fertile soil be joined a want of drainage and a bad treatment (in crowding the individual trees and not permitting a free circulation of air), there is a tendency to disease in teak. I think no one will deny this. Almost every writer that I have studied, Sir D. Brandis in Burmah, Mr. Bourdillon in Travancore and all the various officers who have written about Nilambur have shown, that on a soil which is not well drained, teak will not grow, or if it does grow the wood produced is of poor quality. This, I maintain, is not due to the excess fertility of the soil but to want of drainage. There is a magnificent example of this at Nilambur. One compartment, known as Eddacod 1846 (date of planting) consists of a rich alluvial soil on which there are about 70 trees to the acre, or perhaps more. The quality of the wood is superb, as is shown by certain windfalls which were collected and sold last year realizing nearly Rs. 2 the cft. in the plantation. But in one corner the ground slopes towards the river, and there forms a small plateau, which is flooded nearly every year and on which the water stands. This corner is also planted with teak, and to all appearance the trees are sound, but a careful examination shows them to be hollow to the core. Mr. Hadfield will remember a nice log we saw lying on the bank. We wondered why it was not taken with the rest, as from a distance it looked beautiful, but on close examination we found it quite a shell, hollow up to a length of 60 feet.

Now I come to the point that these quickly grown trees do not produce timber of the finest quality. The Nilambur plantations are a standing testimony to contrary. It is on the richest soils, provided always that the drainage is good, that we expect the best crop. The oldest plantation is now 50 years of age, and stands on a rich alluvium. The measurements in this plantation, as a whole, are given in your March number. I have estimated that the average girth of 6'-6" at breast height will be obtained in this plantation in about the 90th year. At present there are no signs of decay, and the timber even of the biggest trees, which reach 8 feet in girth, is excellent. The Persian Gulf traders, who are no fools, buy up the big timber of the windfalls with alacrity; whilst the Moplahs, who are shrewd men of business, will offer fancy prices for the bigger trees as they stand. All this is evidence to show that the plantation teak is good timber, though grown fast on a rich soil. But why should this be different to the natural grown timber of the Nilambur Valley which gives some of the much valued Malabar Teak. The teak from Nellikutta and Kareenpoya blocks, though grown on a low-lying, rich alluvial soil has been worked for years, and there are no signs of fungoid decay. On the contrary, except for parasitic growth, the wood would be splendid, and I fancy much must have found its way to the Bombay dockyards. So much for indirect evidence, but we have also direct evidence on the quality of the plantation teak.

In 1876, I think it was, Col. Beddome raised this very question, and on it stopped planting. This annoyed Mr. Ferguson who protested all he knew. Canny Scot that he was, he was not going to have this improved argument shoved down his throat. He sent specimens cut from the plantations of about 30 years old (and you may be sure they were from the quickest grown trees as he was so proud of them) to the Superintendant of the Gun Carriage Factory to be tested with Malabar (natural grown), Anamalai and Pegu wood. The result was as follows :-

In order of density came - (1) Anamalai, (2) Malabar (natural), (3) Nilambur, (4) Pegu. In order of resisting strain - (1) Malabar, (2) Nilambur, (3) Anamalai, (4) Pegu. Considering the specimens sent were young timber, I do not think that the trial showed that the plantation teak was not of the finest quality, and the Superintendent's certificate was very favourable.

Specimens were also sent to the Paris Exhibition, where they were much admired, and no fault was found with the quality of the wood.

Coimbatore District, P.M. LUSHINGTON.
8th May, 1895.

LETTERS TO THE EDITOR
(I)

To,
The Hony. Editor,
Indian Forester,
P.O. New Forest, Dehra Dun

Sub **: An ecological audit of teak plantations in West Chandrapur Project Division.**

Dear Sir,

It is learnt from the local press that Madhya Pradesh Rajya Van Vikas Nigam Limited is in grave financial distress. In the circumstances, a reference to the article on the above subject printed in *Indian Forester*, April 1993, pages 265 to 294 is very valid. The authors have conducted a very detailed study. In Maharastra, Forest Development Corporation raised large scale teak plantations, replacing the natural forests. In 1987, FDCM was asked to totally stop this activity in the interest of preserving ecology/plant diversity of the natural forests. The authors have concluded "The apprehension that, large scale clear-felling of natural forests followed by teak plantation, will result into loss of plant diversity, has proved to be ill-founded.... It would, therefore, be inappropriate to discard the system of clear felling and planting...".

Similar situation took place in Madhya Pradesh when M.P. Rajya Van Vikas Nigam Limited also was asked to totally stop such teak plantations. I happened to be associated during 1981-83 as an RGM with the activities of MPRVVN. The patches of highly potential non-teak forests with 0.7 and above density were selected, where into teak was yet to intrude as a natural process, for clear felling and planting with teak, without burning. It was observed that similar results, as are expressed by the authors were apparent. The plant diversity along with teak prospered. It is necessary to tend the entire composition with teak as recommended by the authors. The M.P. Van Vikas Nigam may undertake similar studies and continue to enrich the forests on the experience gained in Maharashtra. Incidentally the Nigam may earn by sale of the produce resulted in this process.

The highly esteemed readers of your only valuable 120 years old journal on forestry may kindly respond : In situations as explained above should the plant diversity be achieved by preservation or conservation ?

Yours faithfully,
sd/-
S.S. Chitwadgi IFS (Retd.)
156/A, Indrapuri, Bhopal (M.P.).

(II)

To,
The Hony. Editor,
Indian Forester,
P.O. New Forests,
Dehra Dun (U.P.)

Sir,

Recently I came across a small Teak plantation in Kharagpur town (West Bengal) raised by M/s Mahapatra Brothers which may interest to the readers.

Only 50 (fifty) stumps were planted in a small piece of land at a spacement of 3m x 3m during September 1993. The stumps were prepared from the seeds collected from older Teak trees at Saptasajja hills in Dhenkanal District in Orissa. Depth of the soil is only 45 cm (alluvial-clay loam type) below which hard morrum layer was met. As a result the depth of pits were restricted to 45 cm also. Section of the pit is 45-60 cm. Average rainfall of the area is 1000 mm. No nutrients were added in the pits. But continuous drip irrigation was done from overhead tank fitted with ordinary polythene pipe pierced and connected with softdrink straws in such a manner that 4 liters of water per day is provided to each plant without stop even in the rainy season. In 1994 rains mounds were made for better anchorage of the plants suitably due to over weight canopies, as there was no leaf shedding even in acute dry spell. The following measurements were taken by me, on 3rd August 1994 in an average line, which appears to be very much encouraging in growth. M/s Mahapatra Brothers are planning to make a tree farm elsewhere with larger areas and designing the thickness of the pipe and the nozzle through which the water will pass at a constant rates without choking the pores.

Sl. No.	Height (m)	Girth (cm)	Sl. No.	Height (m)	Girth (cm)
1.	4.575	13.97	5.	3.660	15.24
2.	2.593	10.16	6.	3.813	11.43
3.	3.660	15.24	Average	3.889	13.865
4.	5.033	17.15	or	3.9 m or	13.9 cm

Highest plant meaured height 5.34m girth 16.5 cm. This is the 11 months growth.

Yours faithfully,
Sd/
S.K. Sarkar
Conservator of Forests,
Development Circle, Calcutta (West Bengal)

(III)

To,
The Hony. Editor,
Indian Forester,
P.O. New Forest,
Dehra Dun.

Sub : Vegetative Propagation (Layering) of Teak (*Tectona grandis*).

Sir,

On 21st April 1995, I had been to Burdi village in Kalahandi Forest Divivion of Orissa. I was accompanied by the Deputy Director and the Assistant Conservator of Forests of the Kalahandi Social Forestry Project Division. The villagers of Burdi took us to the natural Teak Forest which they had successfully protected against the removal of other neighbouring villagers. There was a good growth of coppice shoots in the repeatedly hacked natural Teak patch. While discussing with them, one of the villagers gave us a lesson in vegetative propagation of Teak. He said that by covering a branch of Teak on the ground with soil there will be rooting at every node. He also said that he has raised several Teak plants in his own land by this method and this was corroborated by a few other villagers as well.

This gave to all three of us Forest Officers, revelation because we have never read about or heard such a thing before. We have decided to try it out in Bhawanipatna Central Nursery of Kalahandi S.F.P. Division. This goes to show how much we can learn by interacting with the people. The Deputy Director S.F.P. acknowledged this information with gratitude saying "after serving 32 years as Forester I have learnt a new thing form you. So you are my Guru and as a token of my gratitude I shall give you grafted mango seedlings which are being raised in our nursery under Farm Forestry. Please start making as many pits as you want for planting these mango (grafted) seedlings during the coming rains."

This may be published in the *Indian Forester* for the information of all foresters.

Your sincerely,
Sd/-
K. Jude Sekar
Regional Joint Director
Social Forestry Project
Berhampur (Orissa).

State Forest Service College,

P.O. New Forest - 248 006,
Dehra Dun.

The State Forest Service College, Dehra Dun announces the schedule of courses for inservice S.F.S. Officers for the Academic year 1995-96.

Description of the Course	Schedule
I. **Computer Applications in Forestry** (Three Weeks)	1- 12.06.95 to 30.06.95 2- 04.09.95 to 23.09.95 3- 27.11.95 to 16.12.95
II. **Refresher Course in Forestry**	1- 12.06.95 to 24.06.95 2- 18.09.95 to 30.09.95 3- 27.11.95 to 09.12.95 4- 23.01.96 to 04.02.96
III. **Thematic Course on "Forestry and Rural Development"** (Two Weeks)	1- 04.09.95 to 16.09.95

Nominations are invited from
the Principal Chief Conservators of Forests
and
Managing Directors of Forest Corporations
of the respective States, well in time.

ICFRE Publications

available for sale

1. **Insect Pests** of *Dalbergia sissoo* **sp.**
   by H.R. Khan Price Rs. 300/-
2. **Forestry Statistics,1995**
   Price Rs. 100/-
3. **Annotated Bibliography** on *Dalbergia sissoo,* **Roxb.**
   (Symbol No. ICFRE-25) by N.K. Joshi, P. Bhatnagar,
   Malbika Ray and A.K. Sharma
   Price Rs. 150/-
4. **Food From Forests**
   (Symbol No. ICFRE-13) by S.S.R. Bennet and Others
   Price Rs. 400/-
5. Forest Seed
   (Symbol No. ICFRE-7) by P. Khullar, R.C. Thapliyal, B.S. Beniwal,
   R.K. Vakshasya and Ashok Sharma
   Price Rs. 27/-
6. **The Common Commercial Timbers and Their Uses**
   by H. Trotter
   Price Rs. 27/-
7. **Thirty Seven Bamboos Growing in India**
   (Symbol No. PFRI-232) by S.S.R. Bennet and R.C. Gaur
   Price Rs. 600/-
8. **Advances in Pulp and Paper Research in India**
   (Symbol No. ICFRE-15) by S.V. Singh, A.K. Raj and Rita Dhawan
   Price Rs. 400/-
9. **Composite Wood Research and Development**
   by K.S. Shukla and S.P. Singh
   Price Rs. 200/-
10. **Surface Mined Lands, Problems and Prospects**
    by P. Soni, H.B. Vashistha and Om Kumar
    Price Rs. 150/-
11. Brochures on all important Indian multipurpose tree species
    @ Rs. 20/- each.

Write for details and list of other publications to

NATIONAL FOREST LIBRARY
& INFORMATION CENTRE
P.O. New Forest, Dehra Dun - 248 006.

Failure of Plantations? Damage and Loss of Crop?
Menace from Cattle, elephants, theft?

Electrocuted

But this isn't the way to protect your property. It is illegal and extremely dangerous.

Let the Sun care for your crop and protect your property

Use Power Fence totally dependant on Solar Energy. Easy to install, economic safe and the most effective. Works day and night even in remote areas. No licence needed. Environmentally clean. Requires minimum maintenance.

City Office :
6, Sameera Complex ,
1st Main, Seshadripuram
Bangalore - 560 020, India
PH : 362255, FAX : 080 - 395522
GRAMS : POWER FENCE' BANGALORE - 560 020

Please write to

SURAKSHA ENERGISERS

Regd. Office :
57, Amarjyothi Layout,
P.B.No. 3248, R.T. Nagar
Bangalore - 560 032, India
PH : 333666, FAX : 080 : 641534
TELEX : 0845 - 5405 GLASS IN

REGIONAL OFFICES AND SERVICE CENTRES :

BOMBAY :10-83 Satyanivas, J.B. Nagar, Bombay - 400059, Ph : (022) 8323210: **GUWAHATI** : Rajgarh Link Road-1 Opp. Commerce College, Chandmari, Guwahati - 781 003: **DAKSHINA KANNADA** : Canara Agro Systems, K.S.R. Bdgs. Mangalore - 575001: **KUNDAPURA** : Shetty Radio Electricals, Municipal Road, Kundapura - 576201

GSFDC - Taking up the challenge of tribal development

Gujarat State Forest Development Corporation Ltd. reaches out to tribals and the rural poor in the State through forest based trades and industries. Since inception in 1976, many developmental activities have been undertaken by us. A few of them are :

Minor Forest Products :

Collection, processing and marketing of over 55 economically important Minor Forest Products including Bidi Leaves, Non-Edible Oil Seeds, Mahuda Flowers, Gums, Honey, etc.

Medicinal Products :

Launching "DHANVANTARI PROJECT" for preparing value added herbal based medicines which has already brought 24 Ayurvedic preparations including Chyavanprash to the market.

Wood Products :

Wood Working Unit known as "VANIL UDYOG" in a tribal area where about 400 tribal artisans are provided sustained industrial employment and where facilities for seasoning and chemical treatment of timber have been created for manufacturing quality wooden products, such as, doors, windows, furnitures, etc.

Plantation Projects :

Managing the forest areas and plantations in Valsad district and Irrigated Plantation Project in Panchmahals district aimed at environmental improvement, production of timber, bamboos and firewood.

Other Welfare Activities :

Undertaking other tribal welfare activities, such as environment education, medical camps, seedling distribution etc.

Gujarat State Forest Development Corp. Ltd.
"Vanganga" 78, Alkapuri,
Vadodara - 390 005.

TV ADS

VISION

IN OUR

EYES

FARMERS

IN OUR

HEARTS

USE IFFCO NPK

From 1967 to this day, our vision has grown with the needs of farmers. With an effort to bring them, top quality fertilisers, seeds and pesticides, IFFCO has again set its eyes on increasing its capacity to more than two times of its present position by the turn of the century. Major steps in this direction are expansion of our existing plants and setting up joint venture nitrogenous plants to provide quality fertilisers at reasonable rates to the farmers. IFFCO continues to improve the quality of life of farmers, and increase agricultural productivity by educating them in latest farming techniques, including balanced use of plant nutrients, besides developing tribal and backward areas and undertaking other welfare projects.

IFFCO

INDIAN FARMERS FERTILISER COOPERATIVE LIMITED
34, Nehru Place, New Delhi - 110 019

IFFCO WORKING FOR THE FARMERS FOR DECADES

ALAKANANDA/2/94

HIMACHAL PRADESH STATE FOREST CORPORATION LIMITED, SHIMLA.

With Best Wishes

* With complete nationalisation of forest working viz; timber operations, resin tapping etc. both in Government and private forests, there is complete elimination of contractors agencies and the incidence of illicit felling in forest is under control.

* Corporation extracts high grade deodar, kail, chil, fir and spruce timber and resin by modern methods, produces ISI standard rosin (X to D grades) and non ISI 'B' grade and turpentine oil. All resin tapping has been done by Rill method during 1992 resin season and resin yield per section increased from 32 qtls. (1988 season) to over 41 qtls. (1992 season). Production of pale grades, registered improvement from 52% to 79%. There is no damage to the trees by Rill method.

* Large number of timber and fuelwood depots have been established at convenient location for the benefit of general public.

* In order to maximize operational efficiency, following steps have been initiated:

a) Financial data is analysed through computer net-work to ensure prompt and efficient working and decision making.

b) Providing incentives to officers and staff through prompt action on service matters like confirmation, job rotation vis-a-vis career planning including specialised training.

c) Centralisation of provident fund account of entire staff has been done through computer besides pay-bill centralisation.

* Inspite of meeting the social needs, it is a profit earning organisation.

B.S. Chauhan
Managing Director

TAMIL NADU FOREST PLANTATION CORPORATION LIMITED

(A Govt. of Tamilnadu Undertaking)

Registered Office : AA/26, Anna Nagar, Tennur,
Tiruchirapalli - 620 017.
Tamil Nadu.

Phone : (O) 23314
(P) 469352
Fax - 0431 - 469352

Activities :

1. Raising 500 ha. of mechanised pulpwod plantations every year to meet the pulpwod needs of Paper Mills.
2. Raising 1000 ha. of Cashew Clonal plantation with high yielding varieties, supply of about 1 lakh Cashew clonal seedings to farmers and Departments.
3. Supply of 35000 tonnes of firewood to the public in the form of stumps and lop and top.
4. Harnessing every drop of water in the plantations by effective water-harvesting technology.
5. Effective utilisation of Bio-fertilizers in Nurseries and plantations for maximum yield.

Managing Director

Visit PERIYAR TIGER RESERVE

Thekkady (Kerala State)
(Open All Year)

Observe :

Elephants, Gaur, Sambhar, Leopard, Wild Dogs, Black Langur, The Giant Malabar Squirrel, Birds and other indegeous Fauna.

Hotels :
Western Style - Aranya Nivas
Indian Style - Periyar House.
(Accommodation in Hotels reserved by Managers)
*Finished Forest Rest Houses at Thekkady and Edappalayam.
*Elephant rides.
*Approachable by Air or Rail up to Cochin or Madurai.
Distance to Thekkady by road is 190 km from Cochin, 145 km from Madurai and 100 km from Kottayam.

For further particulars contact : WILD LIFE PRESERVATION OFFICER
Thekkady P.O., (Kerala) Telephone : KUMIL~~Y (04869)~~-22027

Please Contact us for :

Planting Teak, Simul Trees in your land. We have already planted above six lacs trees on Indo-Nepal Border in North Bihar and the trees are 4-6 years old.

NATURAL AGRO
PLANTATION
Basanpur Road,
P.O. Birpur
Distt. Supaul (Bihar)

Associate yourself with the

INDIAN FORESTER

as

Advertiser-Subscriber

or

Contributor

WITH CHAIN BRAKE ATTACHMENT

McCulloch. The Professional Dealer Choice

THE PROFESSIONAL
McCULLOCH
REPLACEABLE SPROCKET TIP

The world's best power chain saws made by "McCULLOCH CORPORATION" Tucson, Arizona, U.S.A., the most experienced people in the field. McCulloch's the NUMBER ONE SELLER of Chain Saws in the world.

SPECIAL FEATURES :

1. Rugged Dependability.
2. Easy Maintenance.
3. Economical in operation.
4. Best Combination of Bar, Chain & Sprocket
5. Capable of cutting any type of HARD wood even harder than concrete.
6. Bar length available 24".
7. All essential spares are readilyavailable.

McCULLOCH CORPORATION exclusive features only on McCulloch Saws :

"Faster cutting with less effort in all type of timber"
"Safe-T-Starter".
Snap lock air filter cover.
"Chain Brake safety feature stops moving chain in miliseconds to reduce the hazards from kick back".
Electronic Ignition.

Fax : 91-011-2214147

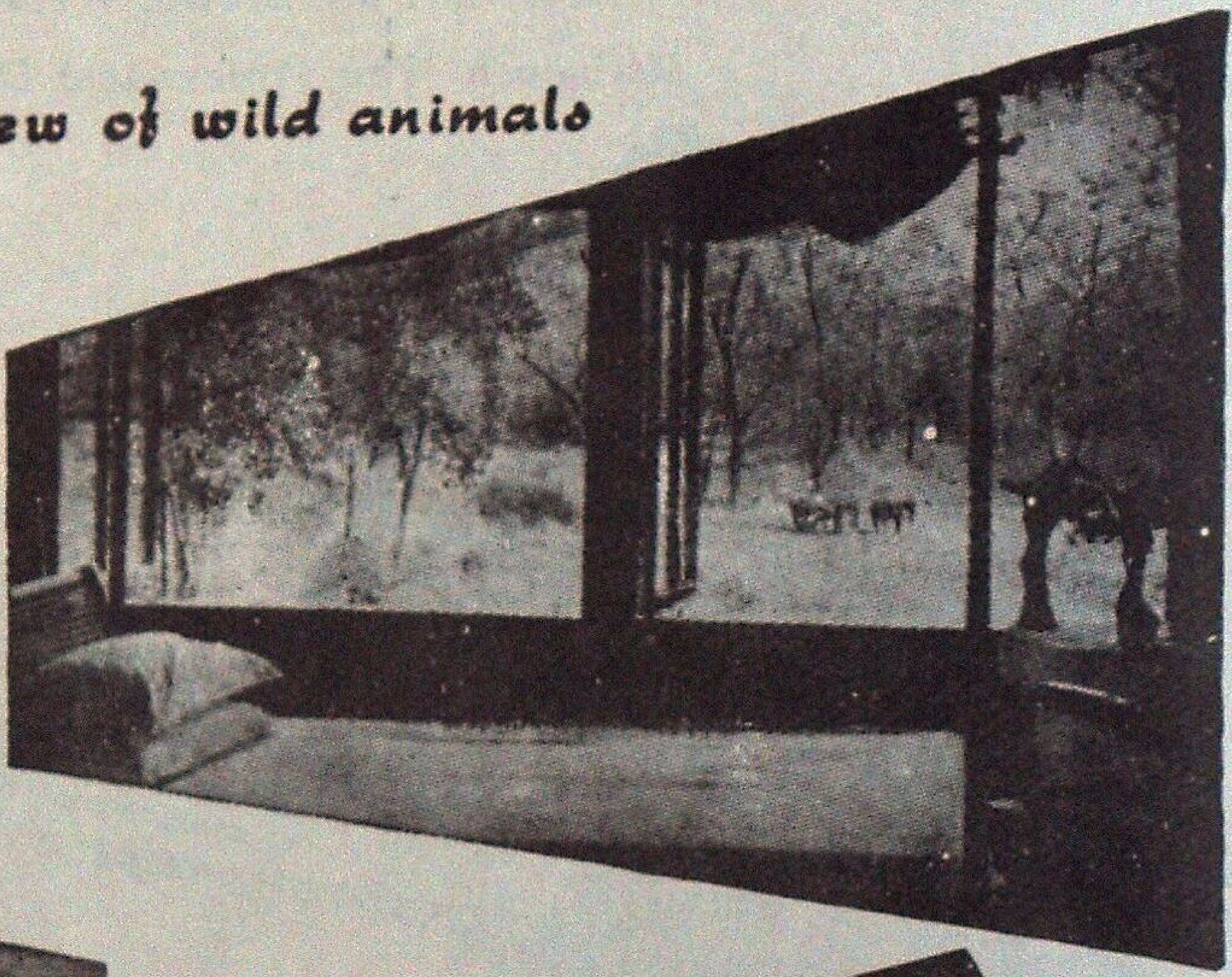
Please contact : "SOLE DISTRIBUTORS in India".

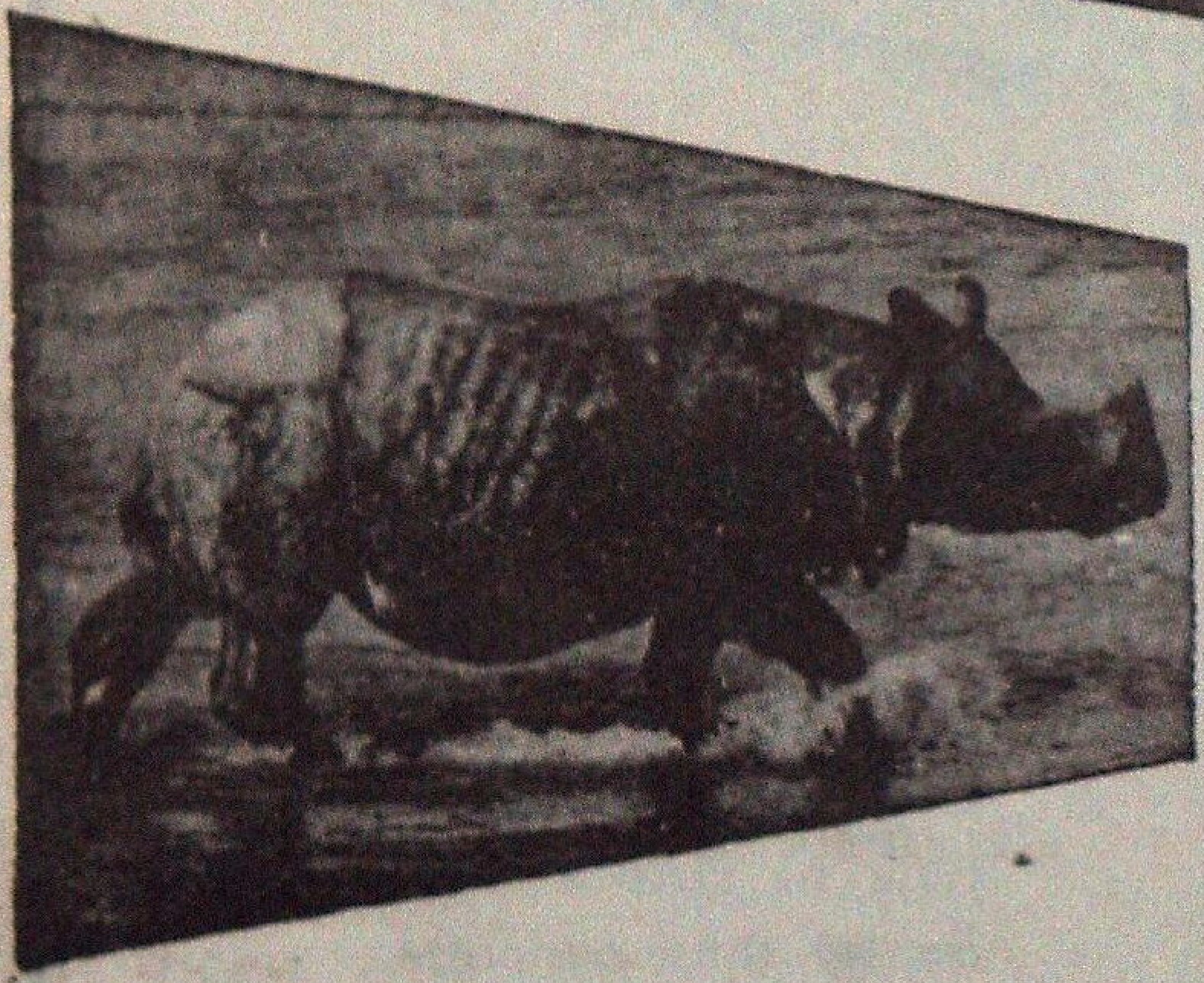
M/s. Indiana International

2001, Ugger Sen Street, Bazar Sita Ram, Delhi-110006
Phone : Office : 734868, Gram : "POWERCHAIN"
Res. Address : F-42, PREET VIHAR, DELHI-110092 Ph. : 224-2737, 221-4147

Have a bedroom view of wild animals

VISIT





JALDAPARA WILD LIFE Sanctuary

- Home of One-horned Rhinoceros.
- Gaur, Elephants, Tigers.
- Varieties of Deer and other Animals.
- Furnished Tourist Lodges with full Catering arrangement.
- Approachable by Road, Train and Air.
- Jeep available.

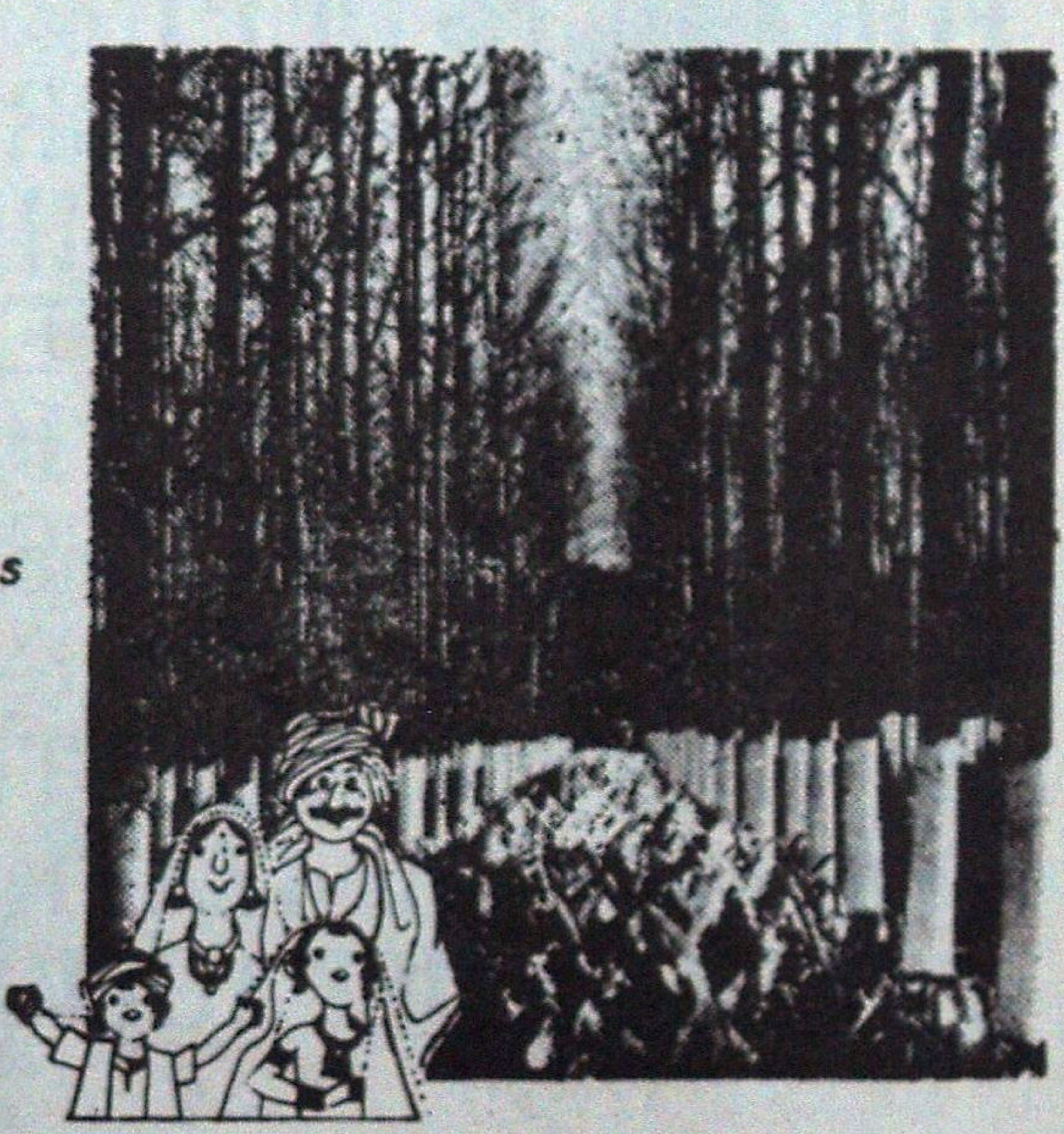
Please Contact :

DIVISIONAL FOREST OFFICER
WILD LIFE DIVISION-II
JALPAIGURI
(WEST BENGAL)
OR
FOREST UTILISATION OFFICER
8, Lyons Range, CALCUTTA
(Phone : 20-2774)
WEST BENGAL

AGRO-FORESTRY

A New Dimension

Fast-growing Poplar and Kadam trees have opened the way for farmers to maximise land use and returns under Wimco's agro-forestry programmes. In the process, generating vast quantities of wood for various industries, and helping improve the environment too.



Wimco provides:

- ★ *High quality planting material.*
- ★ *Extension services and technical guidance till harvest.*
- ★ *Assistance in obtaining bank loans to meet cost of inputs.*
- ★ *Assured minimum prices for the trees.*

Areas covered

Poplar

U.P. : Meerut, Ghaziabad, Saharanpur, Muzaffarnagar, Haridwar, Dehra Dun, Moradabad, Nainital, Rampur, Bijnore, Aligarh, Bulandshahr, Bareilly, Shahjahanpur, Pilibhit, Lakhimpur Kheri, Hardoi, Badaun, Etah, Bahraich & Sitapur.

Punjab : All Districts

Haryana : Karnal, Panipat, Ambala, Yamunanagar, Kurukshetra, Sonepat, Hissar, Jind, Sirsa, Rohtak & Faridabad.

Kadam

Assam : All districts (Brahmaputra Valley)

U.P. : Barabanki, Faizabad, Basti, Deoria, Gorakhpur, Maharajganj, Sidharthnagar, Gonda.

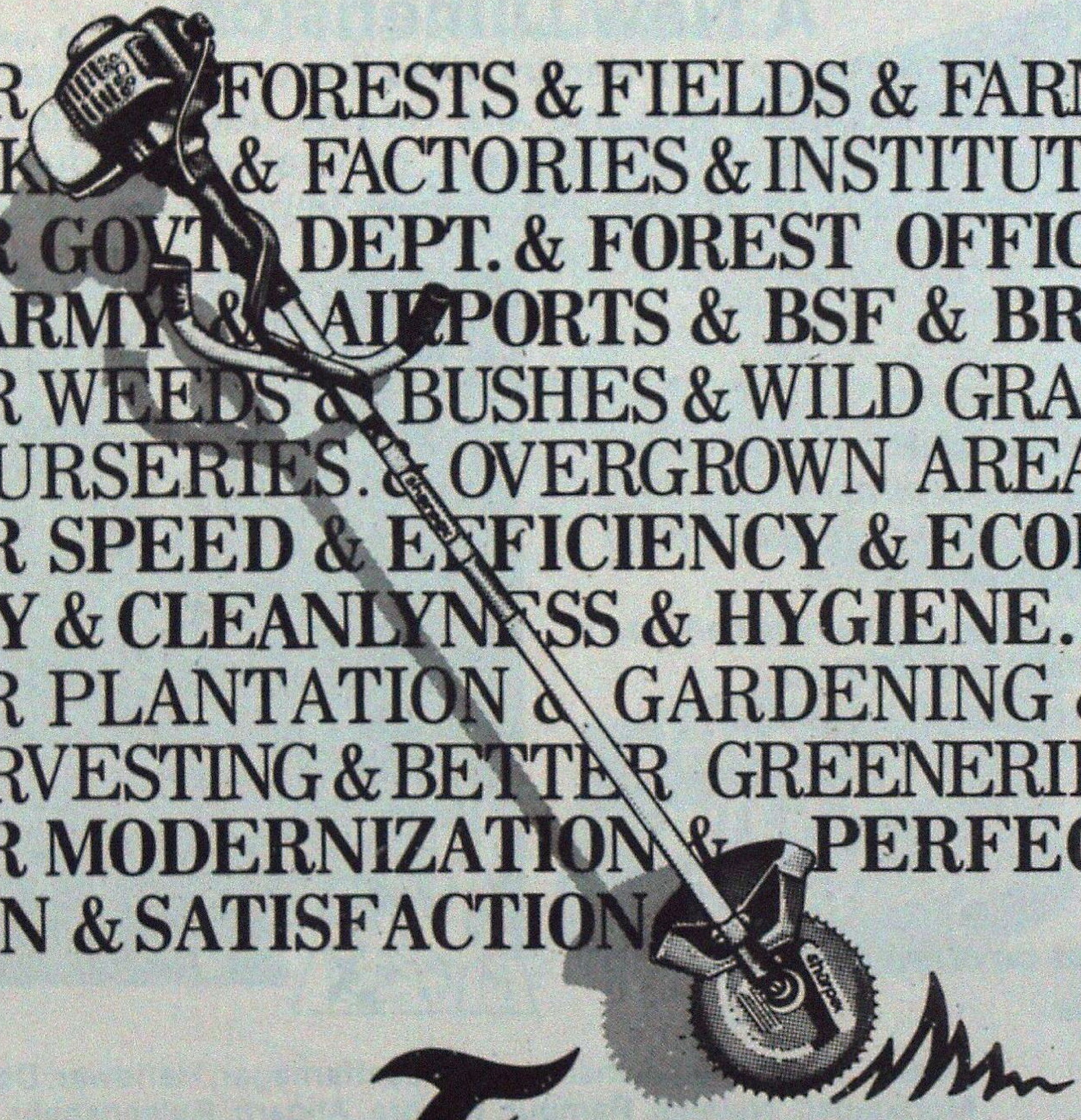
WIMCO

WIMCO LIMITED

AGRO-FORESTRY DIVISION

5E, LOCAL SHOPPING CENTRE,
MASJID MOTH, NEW DELHI-110048.
PH.: 6451913, 6461947, 6462319, 6429614, FAX: 011-6462747, TELEX : 71158 WMCO IN

FARMEX



FOR FORESTS & FIELDS & FARMS
PARKS & FACTORIES & INSTITUTES.
FOR GOV'T. DEPT. & FOREST OFFICES
& ARMY & AIRPORTS & BSF & BRTF.
FOR WEEDS & BUSHES & WILD GRASS
& NURSERIES. & OVERGROWN AREAS.
FOR SPEED & EFFICIENCY & ECONOMY & CLEANLYNESS & HYGIENE.
FOR PLANTATION & GARDENING &
HARVESTING & BETTER GREENERIES
FOR MODERNIZATION & PERFECTION & SATISFACTION

Farmex
Automatic Weed Cutter

FARMEX DOES IT FASTER

Farmex is from Sharpex-the 1st Indian chain-saw manufacturers. Farmex cuts wild grass, weeds, thick bushes, however tall and dense-at a very high speed.

Thus it saves on time & labour, proving itself extremely economical. Farmex is compact, light weight, handy and truly portable. This simple, engine driven machine can be handled by just one person with a real working pleasure !

sharpex®
Engg. Works
Plot No. 1-5,
Nr. L. Type Sheds, GIDC,
Phone : 870075, 871342
Telex : 0121-6979 SPX - IN
Fax : 079-871341

mānav media

KHANNA BANDHU

7, Tilak Road, (1st Floor), Dehra Dun - 248 001

LIST OF OUR PUBLICATIONS

English

1. Principles and Practice of Silviculture. - L.S. Khanna
2. Forest Protection. - L.S. Khanna
3. Management of India's Forest Resources - A.N. Chaturvedi
4. Technology of Forest Nurseries - A.N. Chaturvedi
5. Wildlife (Protection) Act - 1972 as amended up to date (1993) with commentry - L.S. Khanna
6. Hand Book of Forestry - L.S. Khanna

हिन्दी में

1. वनवर्धन - (Silviculture) - एल० एस० खन्ना 'पुरस्कृत'
2. वन विज्ञान (वनवर्धन पद्धतियाँ, वन मापिकी तथा वन प्रबन्ध) 'पुरस्कृत'
   (Forestry - Silvicultural Systems, Forest Mensuration and Forest Management - एल० एस० खन्ना
3. वन उपयोग (Forest Utilization) - एल० एस० खन्ना 'पुरस्कृत'
4. वन अभियान्त्रिकी (भवन निर्माण) - एल० एस० खन्ना 'पुरस्कृत'
   [Forest Engineering (Building Construction)]
5. भारतीय वन अधिनियम मीमांसा - एल० एस० खन्ना 'पुरस्कृत'
   (Indian Forest Act - A critical study)
6. वन सर्वेक्षण (Forest Survey) - एल० एस० खन्ना 'पुरस्कृत'
7. वन मार्ग तथा पुल - एल० एस० खन्ना 'पुरस्कृत'
   (Forest Roads and Bridges)
8. वन रक्षण (Forest Protection) - एल० एस० खन्ना
9. वन्य-जीव संरक्षण तथा प्रबन्ध - एल० एस० खन्ना 'पुरस्कृत'
   (Wildlife Conservation and Management)
10. वन लेखा एवं प्रक्रिया - एल० एस० खन्ना
    (Forest Accounts and Procedure)
11. सौ उपयोगी वृक्षों का वनवर्धन - एल० एस० खन्ना
    (Silviculture of Hundred Useful Trees)

Maintaining the harmony of the **hills and forests** *by keeping its produce pure and its people free.*

The lush forests and hills of Andhra Pradesh are home to a beautiful people, the tribals. Gathering forest produce and cultivating a few crops, they live a simple life in harmony with nature. The rich variety of produce from these remote and happy lands find a ready market all over the world.

To keep the Tribals Smiling :

GCC has many functions. But its very *raison d'etre* is to keep the tribal smiling. To keep them free from exploitative middlemen, petty traders and usurious money-lenders. This is achieved by meeting their credit requirements in easy, convenient and effective manner. By purchasing forest produce from them at fair prices. By purchasing agricultural produce from them at competitive prices. By supplying daily requirements and essential commodities to them at economical prices. By imparting scientific training to them in gathering or tapping of forest produce so that yield could be increased, without endangering the trees and environment. By collecting the forest produce at the very doorstep of the tribals. By gaurding against deterioration and degradation. By researching to find better scientific gradation and storage techniques.
By proactive search for adding new MFPs to the list.

To maintain Harmony with Nature :

The Corporation completely appreciates the need for maintaining harmony with the nature and also realise that mere lip service is not at all enough for achieving this goal. Active research initiatives are on to find out new uses and thereby increasing the value of various produce namely seeds, fruits, bark, gums, leaves, etc. of the trees. Significant breakthroughs have already been achieved. The key premise is that assigning economic value to the non-timber uses of the entire range of trees available in the forest will promote the conservation of trees and forests.

A team of hardcore professionals is handling the marketing of these value added derivatives under CRD (Commercialisation of Research and Development) Division.

Big and Dependable :

GCC, is one of the largest agencies in India for these products. GCC has exclusive rights to procure Minor Forest Produce in the forest areas of Andhra Pradesh. The Corporation serves nearly 2 million tribal population spread over 30,000 square kilometers. This mammoth enterprise functions through a net work of 2 Regional offices, 12 Divisional offices, 46 Branch offices and 817 Depots, besides numerous godown points and a large transport fleet. The infrastucture ensures timely and effective service to tribals on the one hand and the consumers on the other.

Products Marketed By GCC :

Food Items: Honey: Tamarind: Tumeric: Cashew : Dry Chillies: Pepper: Ginger : Garlic: French Beans (Rajmah) **Gums:** Gum Karaya: Gum Olibanum : Gum Dikamali: Gum Tiruman. **Cosmetic Items:** Sheekakai: Soapnuts:Citronella oil: Turmeric. **Oil Seed:** Niger Seed: Pungum Seed: Mohwa Seed: Neem Seed: Kusum Seed. **Medicinal Items:** *Pippalamodi : Nuxvomica : Myrabolns: Amla.* ***Medicinal Herbs:*** *Adhatoda vasica: Butea monosperma: Cassia angustifolia: Centella asiastica: Piper longum Lawsonia inermis : Hemidemus indicus : Withania somnifera: Tinospora cordifolia.* **Others:** Cleaning Nuts: Tamarind Seeds: Palm Fibre: Adda Leaves: Bees Wax.

Value Added Products :

Gum Karaya: Tablet binder, Disintegrater, Tooth paste binder, Laxative mix, Denture Adhesive Creams/Powders, Texoprint Gums, Ostomy Aids. **Gum Olibanum:** Oil and Oleoresin. **Turmeric:** Oil and Oleoresin. **Marking Nut:** BNSL (Bhilwanol Nut Shell Liquid). **Medicinal Herbs:** Powder/Extracts.

For Other details direct your enquiries to :
Girijan Co-op. Corpn. Ltd.,
Visakhapatnam - 530 017, Andhra Pradesh, India.
Telephones : 551964, 554261 (3; lines) Telex - 0495- 249 SEVAIN
Grams - 'GIRIJAN' FAX- 91-891 - 554245

FORESTS - The Green Gold
of
ANDAMAN & NICOBAR ISLANDS

"Forests, in its pristine glory, if it is found anywhere in South-East Asia, it is in Andaman Islands." - Sir Harry Champion

* The reserved and protected forests extend over 86.5% area of the territory.
* More than 50% of the forests have been set aside as Tribal Reserves, National Parks and Wild Life Sanctuaries, which are in-violate.
* Luxurient Mangroves, perhaps the richest in the world, occupy nearly 11.5% of the territory.
* More than 150 plants and animal species are endemic in nature.
* Wandoor Marine National Park is rich in corals, a variety of coloured fish, sea turtles etc. besides other marine life.

Do not miss to visit the last glory of virgin forests.

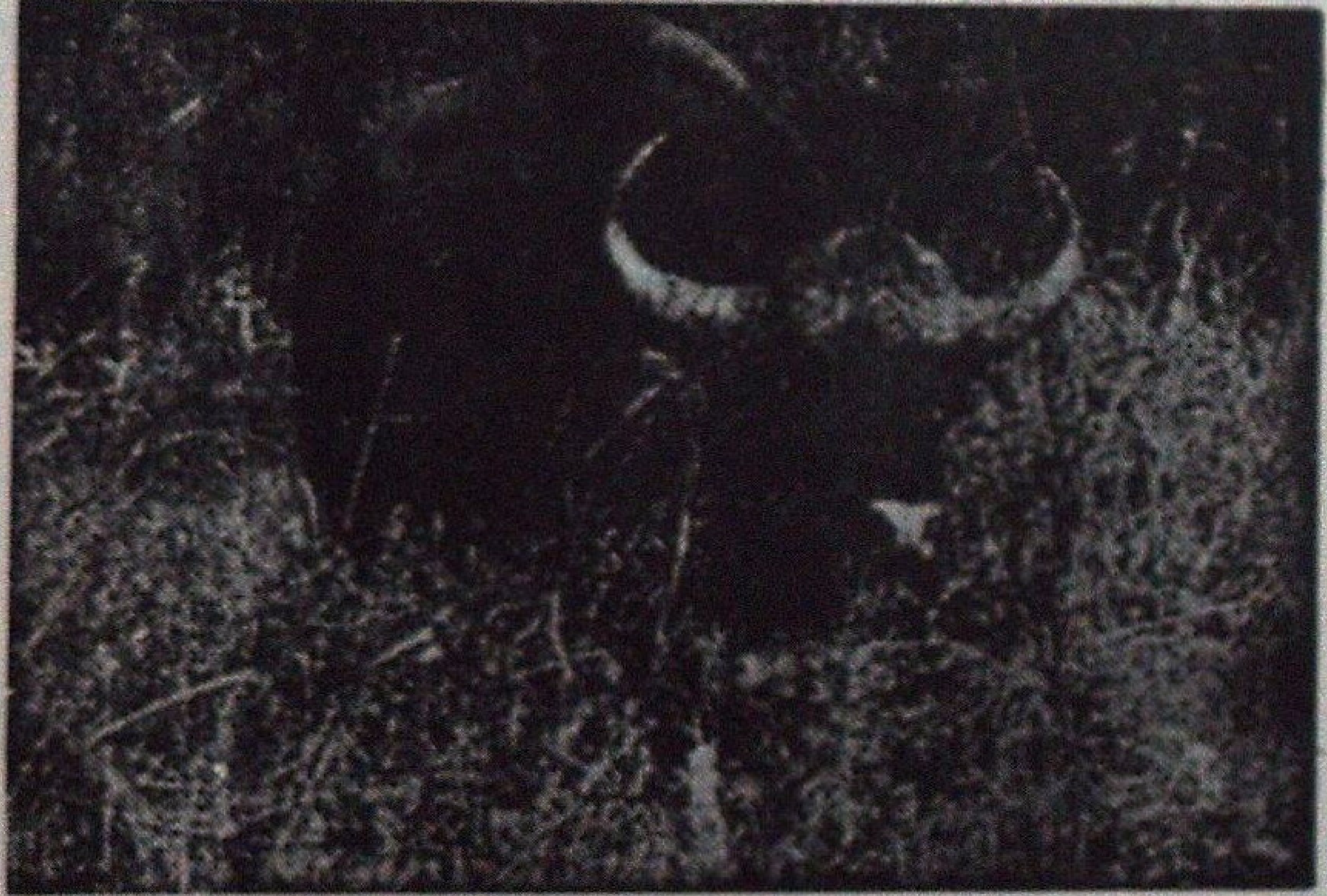
PRINCIPAL CHIEF CONSERVATOR OF FORESTS
ANDAMAN AND NICOBAR ISLANDS

Visit : Palamau National Park

Famous for the abundance and variety of wildlife - Tiger, Panther, Elephant, Gaur, Sambhar, Spotted deer, Barking deer and numerous species of beautiful birds.

* Picturesque Scenery.
* A place of historical importance - the old and the new Palamau Fort of Chero Kings.
* Ideal holiday resort.
* Well furnished tourist Lodges and Forest Rest Houses with catering arrangement.
* Beautiful Watch Towers, tree-top and Hide-outs - all connected by roads.
* Remains open throughout the year.
* Snaps and movie permitted free of charge.

Approachable by road and rail - 26 kms from Daltonganj, 12 kms from Chhapadohar Rly. Station. Well connected by roads with confortable bus service. Nearest Airport - Ranchi - 175 kms.



For further particulars write to :

THE FIELD DIRECTOR,
PROJECT TIGER
Palamau Tiger Reserve.
P.O. Daltonganj, Bihar (India)

AEROPLY

P.F. BONDED B.W.R. GRADE PLYWOOD
THE TOUGH AND LONG LASTING PLYWOOD

Suitable for :
Construction of Rail Coaches, Bus Bodies, Furnitures etc.

IS : 303

ISI

Manufactured by :

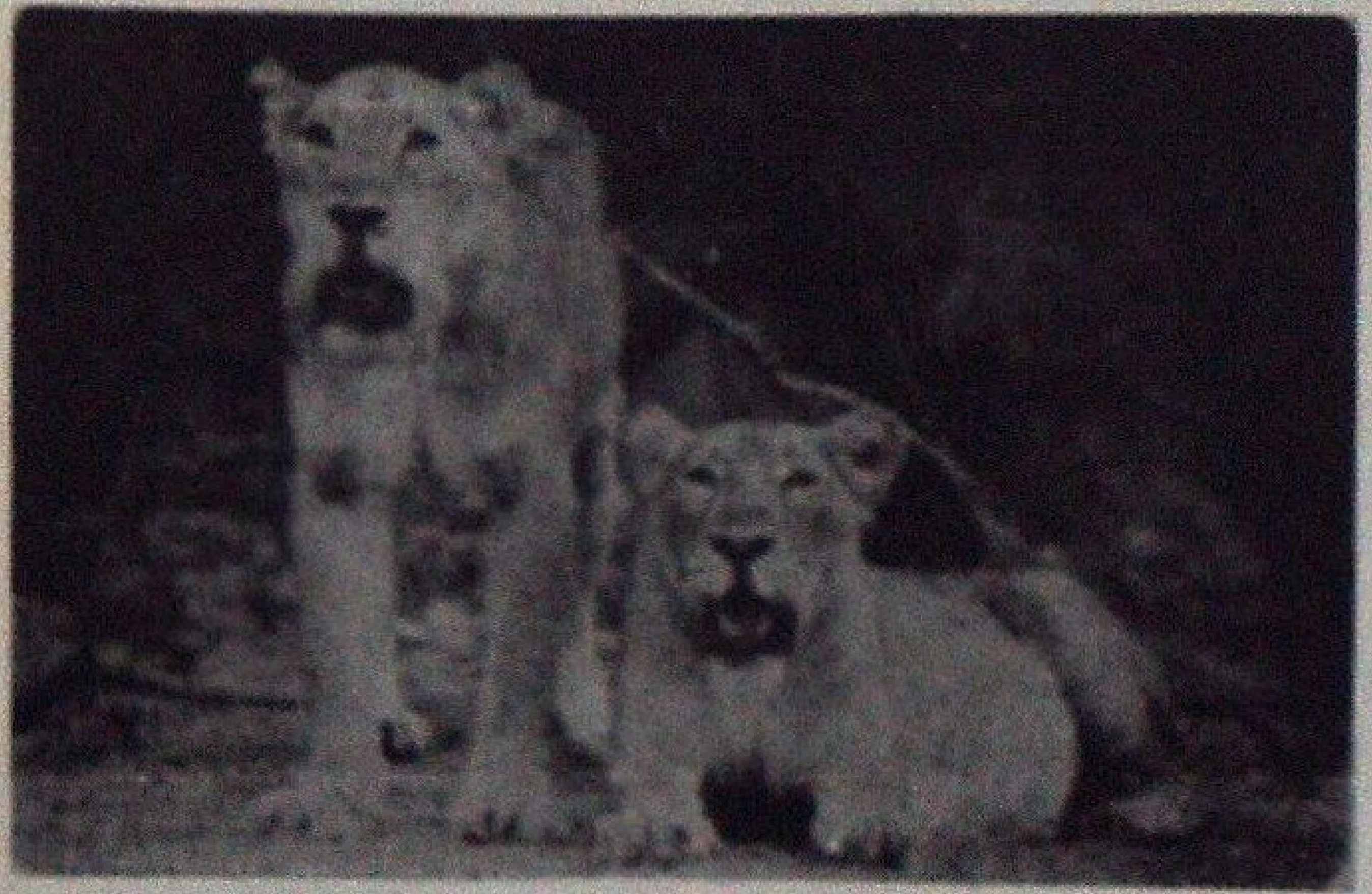
JAY SHREE TEA AND INDUSTRIES LTD.
(Plywood Division)
Laldwara Bldg., New Link Road
Swami Ram Tirath Nagar, New Delhi - 110 055
Phones : 528055, 522797, 7533711

Works :

WOODCRAFTS ASSAM
Mariani (Assam)

JAY SHREE TIMBER PRODUCTS
Bakultala (Middle Andamans)

The Moments of Life Time Experience Await You



IN SASAN-GIR
You have a date with the
King & Queen
of Animal World

The Most Majestic Royal
Animal Species -

The Rare
Asiatic Lion

For more details contact :

Deputy Conservator of Forests,
Wild Life Division,
P.O. Sasan-gir - 362 135
Distt. Junagadh, Gujarat

पर्यावरण सुधार, भू-संरक्षण, जल-संसाधन संर्वधन हेतु

वन निधि का संरक्षण एवम् विकास

समाज
की पर्यावरणीय सुरक्षा
व्यापारिक-औद्योगिक-दैनिक
उपयोग की वनोपज सम्बन्धी
पूर्ति के लिए

वन निधि
का संरक्षण एवम् विकास
नितांत आवश्यक है। इस दिशा
में कामयाब कोशिश की है -
म.प्र. राज्य वन विकास निगम ने

बिगड़े
तथा निम्न कोटि के
वन क्षेत्रों को बहूमूल्य
साधन वनों में बदलकर।

जुलाई १९७५ में स्थापित निगम
ने प्रदेश की वन निधि में अभिवृद्धि के लिए

१९५०९७ है. क्षेत्र में
सागौन बाँस-मिश्रित प्रजातियों का रोपण,

३३८३० हैक्टेयर में
चारागाह विकास तथा ५४१२७ है.
सूखा उन्मुख क्षेत्र में
वनीकरण किया गया है।

इस वन निधि का वर्तमान
अनुमानित मूल्य ४५० करोड़ रू है,

अंतिम विदोहन तक इस
वन सम्पदा का मूल्य ५००० करोड़
रूपये से भी अधिक।

रोजगार
जरूरतमंद ग्रामवासियों को
स्थानीय स्तर पर

७५ लाख मानव दिवस
के बराबर वार्षिक रोजगार
इसमें २६ करोड़ रूपयों की
वार्षिक मजदूरी का भुगतान

कुटीर उद्योग

सबई केतकी
घास से रस्सी निर्माण
हेतु प्रशिक्षण व तकनीकि ज्ञान,

फर्नीचर
आर्कषक, मजबूत
दरवाजे खिड़की पल्ले व
पोलीवेग्स निर्माण एवम् प्रदाय हेतु
नर्मदा वुड प्रोडक्ट्स, इटारसी
के रूप में एकाकी प्रयास.

पर्यावरण सुरक्षा. प्राकृतिक संतुलन. वनोपज पूर्ति.

हेतु दृढ़ संकल्पित

(बी. एस. बसवान)
अध्यक्ष

प्रबंध संचालक

मध्यप्रदेश राज्य वन विकास निगम लि. पंचानन, पंचमतल मालवीय नगर, भोपाल -३
M.P. Rajya Van Vikas Nigam Ltd. Panchanan, Punchamtal Malviya Nagar, Bhopal -3

With Compliments From

Andaman and Nicobar Islands
Forest and Plantation
Development Corporation Ltd.,
(A Government of India Undertaking)
Port Blair

Telephone : 20869
20867
20752
20261

Gram : "VANVIKAS"
FAX : (03192) - 21254

* Deals with the development of forest on scientific principles with minimum disturbance to the local ecosystem.

** *Produces and trades in*
1. Andaman Timber
2. Crude Palm Oil
3. Rubber

Project Offices : 1. Hut Bay, Little Andaman
2. Mayabunder, North Andaman
3. Kapanga, Katchal.

Liaison Office : 1. 106/1, Karaya Road, Calcutta -17.

ITC Bhadrachalam brings you the most significant breakthrough in Clonal Technology

- ★ Pioneers in improvement of Eucalyptus planting stock.
- ★ More than 300 candidate plus trees with outstanding phenotypic characters cloned through rooting of juvenile cuttings.
- ★ Based on 5 years replicated field trials, 35 outstanding fast growing and disease resistant clones identified.
- ★ Clonal planting stock of these 35 genetically superior "Bhadrachalam" clones is now available for commercial plantations.
- ★ Compared to seed root plantations, productivity of clonal Eucalyptus plantations will be 1.5 to 2 times higher and net returns will be higher by Rs. 40,000/ha at 7 years rotation.
- ★ These disease resistant clones ensure extremely fast and uniform growth of plantations with much better wood quality.
- ★ Many State Forest Departments & progressive farmers have planted "Bhadrachalam" clones of Eucalyptus for higher productivity and profits.

ITC BHADRACHALAM
PAPERBOARDS
LIMITED

106, Sardar Patel Road, Secunderabad - 500 003
Phones : 040-846566-73, Telex : 0425-6573, 2030 BPL IN

Karnataka
Forest Devlopment
Corporation Limited

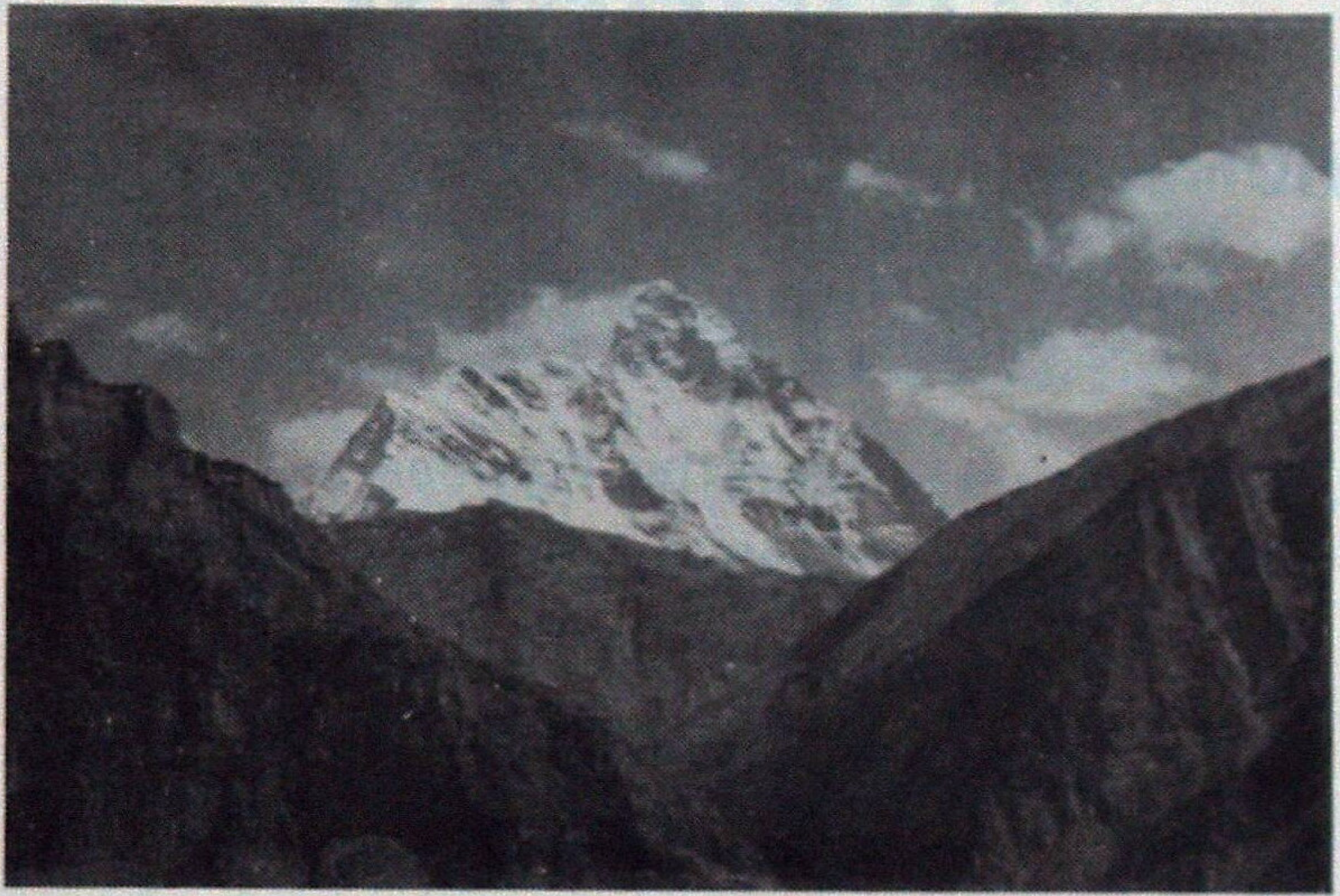
(A Government of Karnataka Undertaking)

Regd. Office : "Vanavikas", 18th Cross,
Malleswaram, Bangalore-3.

Raising of Eucalyptus plantations
with main object of selling Eucalyptus Wood
to Wood based Industries
and sellers of Eucalyptus
Citridora Oil/Bursera Oil
to Aromatic Industries.

Manufactures and sellers of raw Rubber Products,
Like centrifuged latex of 60% DRC (ISI Marking),
Skim crepe, Latex crepe, EDC 1X, 2X, 3X,
Milling Waste,
Waste lump, EBC (off Grade), etc.
to Rubber based Industries

NANDA DEVI BIOSPHERE RESERVE



First Biosphere Reserve in Uttar Pradesh
Established on 18th of January 1988
Total Area 2236 Km^2

Core Zone :	Comprising of Nanda Devi National Park	: 624 km^2
Buffer Zone :	Surrounding the Park (NDNP)	: 1612 km^2
Location :	Himalayan Highlands around Nanda Devi (7817 m) in the civil districts of Chamoli, Pithoragarh and Almora.	

IMPORTANT TOURIST PLACES AND MAIN TREK ROUTES IN BUFFER ZONE

1. Chamoli :	Lata Kharak, Malari, Roopkund.	
	Lata-Latakhark-Suraithota	30 km
	Debal-Wan-Roopkund-Ghat	70 km
2. Pithoragarh :	Milam Glacier	
	Munsyari-Milam-Milam Glacier	60 km
3. Almora :	Pindari Glacier	
	Loharkhet-Khati-Pindari Glacier	50 km

BEST VISITING TIME : 15TH JUNE - 15TH OCTOBER

For More Information Contact

Dy. Conservator of Forests
Nanda Devi National Park,
Joshimath (Chamoli)
Phone No. 2179

Director,
Nanda Devi Biosphere Reserve,
Gopeshwar (Chamoli)
Phone No. 2497

HUNSPLY

HUNSUR PLYWOOD WORKS LIMITED

Manufacturers and Exporters of :

- **Decorative Plywood**
- **Water Proof Plywood**
- **Commercial Plywood**
- **Flush Doors**
- **Block Boards**
- **Decorative Spliced Veneers**

and

Suppliers of First Quality
Burma Teak Round Logs and
Sizes as per required specifications

Registered Office and Factory :
Post Box. No. 2
HUNSUR - 571 105, KARNATAKA STATE

☎ Office : 2140 & 2025
Resi. : 2024

Grams : "HUNSPLY"
Telex : 0846-224 HPW IN

Depots :

1-1-568, New Bakaram, HYDERABAD - 500 020.
100, G.N.T. Road, Polal, MADRAS - 600 066.
122-124, Abdul Rehman Street, BOMBAY - 400 003.

With Best Compliments from :

KITPLY

INDUSTRIES LTD.

Regd. Office :
Rangagora Road, Tinsukia - 786 125.

Head Office :
119, Park Street, Calcutta - 700 016.
Tel.: 29-3340-44, 291666-67, Telex No.: 021 5395

Manufacturers of :

- KITPLY
- Marine Ply
- Shuttering Ply
- Lara Ply
- Decorative Ply
- Chequered
- Fire Retardant Plywood
- Block Boards
- Particle Boards
- Flush Doors

  and
- Electrical Components.

DO YOU EVER CHECK UP ROOT SYSTEM BEFORE PLANTING ?

No hormone no growth. Hormones are of two kinds - growth promoting and growth inhibiting.

Plants grown in nursery beds and in containers are forced to develop geotropic root system with endogenous growth inhibiting hormones. Our nursery plants with hydrotropic root system produce more of growth promoting hormones. The spatial orientation of the root system in soil exerts profound effect on the total biomass production of any tree species.We apply in our nursery these techniques which are evolved by **All India Teak Consultant** C. Jagannath Reddy. Our teak plants are growing at a spectacular rate. All News Papers in Andhra Pradesh published most exciting news about the magic growth of our teak plantations.

Plant nutrition evolved by C. Jagannath Reddy affords boost to the growth and development.

Plants of Sandalwood with Rs. 4 lakhs per ton & Red Sanders with 12.5 lakhs per ton are also grown at our nursery with root system of growth promoting hormones. Booklets on Teak, Sandalwood and Red Sanders are also available for sale.

One can see our Teak Plantations grown with new techniques and with plant nutrition **"Teak Mixture"**.

KAMALA TEAK PLANTATIONS

2-635/2B Nakkalgutta
Hanmakonda (Warangal)- 506001.

Phones :
Warangal : 08712 77671
Hyderabad : 040 637013
040 602545

WITH THE EXIT OF
MIDDLEMEN..............ENTERS
THE PROSPEROUS
& HAPPY TRIBAL.

As the sole agent of the State Govt. for the collection and marketing of nationalished Minor Forest Produce namely Kandu Leaf, Sal seed, Mahua seed & Harra fruit. The Forest Development Corporation has made notable contribution in freeing the Scheduled Tribes and other weaker sections of the people living in and around forests from the exploitation of middlemen and in upliftment of their economic condition.

BIHAR STATE
FOREST DEVELOPMENT
CORPORATION LTD.,

13 - Patliputra Colony,
PATNA - 800 013.

Fax - 262544
Phone -262275, 252283, 262205

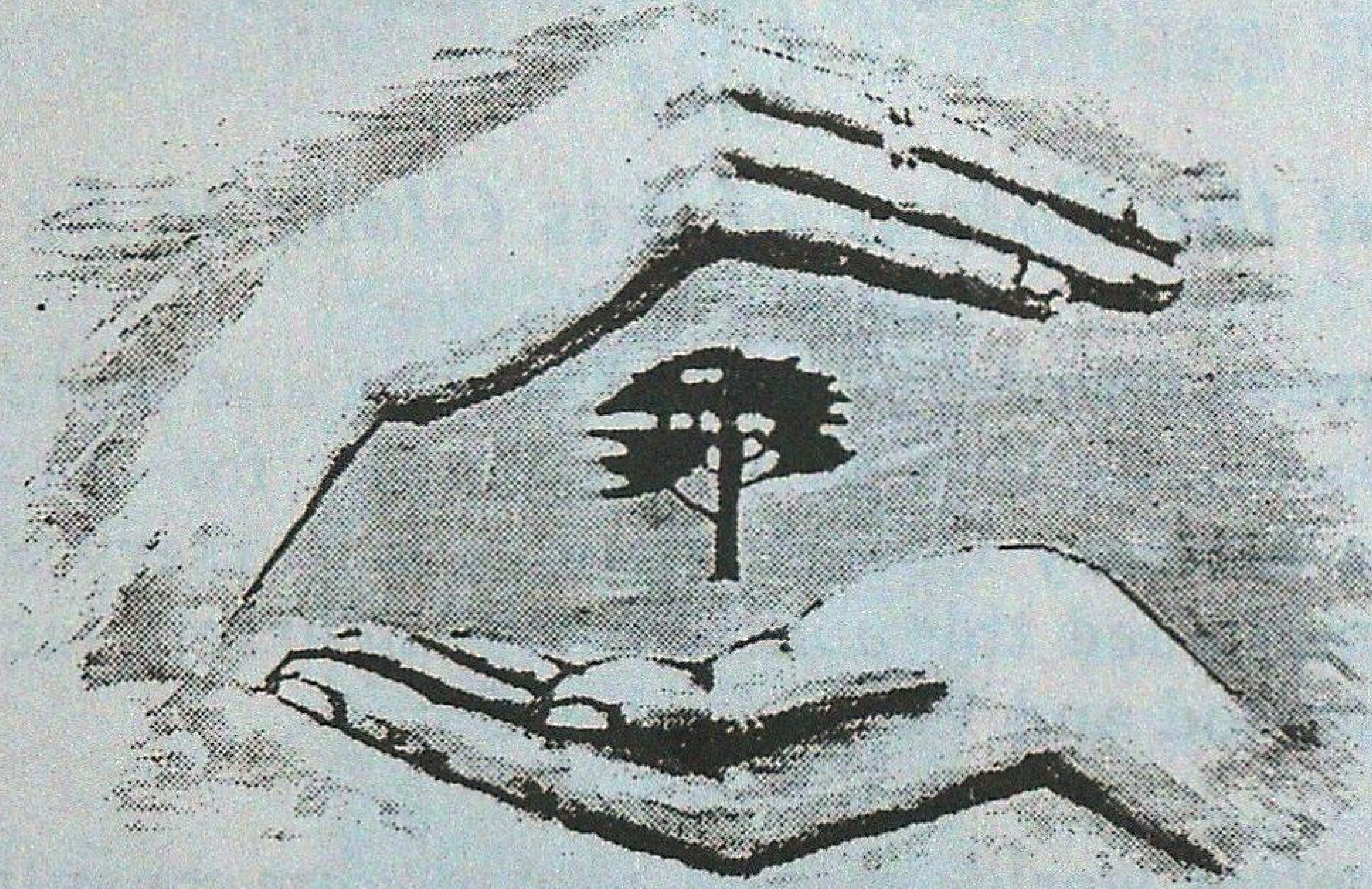
4½ Year Old "Teak Plantation"
Under Drip Irrigation
in
Sanghinagar Hyderabad A.P.

Sanghi
PLANTATIONS LTD

SANGHI PLANTATIONS LIMITED

A Plantation Division of Sanghi Group of Industries.
P.O. Sanghinagar, Hayatnagar Mandal. R.R. Dist - 501511(A.P.)

THEY HAVE SHELTERED US FOR AGES



NOW TREES NEED OUR SHELTER

Are you the sort of person who kills the goose that lays golden eggs? Unfortunately, certain elements of our own society have been ruthlessly cutting down our best friends-the trees, thus endangering themselves as well as the entire mankind. Trees play an invaluable role in maintaining the ecological balance and climate, stabilizing soil and water resources and safe guarding biological diversity.

It is precisely for such purposes that we setup TIMBERWORLD RESORTS & PLANTATIONS. Our singular global commitment is to create more environmental awareness and create an indelible impression for our cause by massive afforestation. In fact our plan envisages planting of 5 million trees over the next few years.

We are confident of your fullest participation in our project, Because we owe it to our ***children*** *to give them a better environment, in close conjunction with nature and our oldest friends-trees.*

TIMBERWORLD

Timberworld Resorts & Plantations India Limited
Corporate Office : M-42, Market Commercial Complex,
Greater Kailash-II, New Delhi-110 048
Phones: 6475545, 6218179, Fax: 6465477

TIMBERWORLD
SAVE
OUR
ENVIRONMENT

CONTINENTAL TW-143-95

Because ....
We Care for the Earth
and
We want the Colour of this Globe to be Green

Lush green forests, beautiful flowers and pollution free world ....this is all we crave for. Leading in indigenous Nursery Development and Nursery Sales, we have accomplished the plantation of nearly 1 lac trees of Teak, Rosewood and White Cedar Plants.

For a better world, we also provide our consultancy for Forestry, Horticulture, Floriculture Projects, undertake Plantation Projects on turn key basis : Beside that we supply all kinds of Plants, Saplings, Flowers and Seeds.

Let Us Make a Beautiful World

H.K. PLANTATIONS
&
ORCHARDS LTD.

Silver Arc Plaza, 7th floor,
20/1, New Palasia, INDORE - 452 001 (MP).

Phone Nos. 431878, 431863
Fax No. 91 - 731 - 431475.

3 reasons STM is in the business it's in.

There are any number of reasons to be environment conscious but the three listed here should suffice.

Our forest resources are going up in smoke. Everywhere the cry goes up, 'Get rid of the woods. We need the wood'. You see, wood is the raw material for many processes and has numerous applications. And the logic being used is that in the interest of progress and commerce, if the forests have to be sacrificed, tough! The point is, it means progress in the short run and a dead planet in the long one.

Of course, we need wood. But maybe...just maybe, we don't need to sacrifice our forests to get it. The trick is in planting trees, lots of trees.

Paste your photograph here

But in today's dog-eat-dog, rat-eat-rat world, who's going to worry about the trees? The answer there is to offer people money to do so. Which is what we at STM have done. Get people to plant trees (or rather adopt them) for which they make money. And so do we, in the bargain!

Ah, did we hear the cynic say 'But you're going to chop down the trees anyway?' Yes, that's true, but since our plantations will provide the wood needed by the nation, there will be no need to level our forests. It's just like farming.

Pretty interesting, huh? And remember, one day, your children may thank you for leaving them a better world.

STM

STERLING
TREE MAGNUM
(INDIA) LTD.

'DIVYAA' 8A MURRAYS GATE ROAD
ALWARPET, MADRAS 600 018.

Lintas Mds Stm DJ 2418

SALE SALE SALE

A few copies of the following Special Issues of the *Indian Forester* are in available for sale :

1.	January, 1975	Indian Forester Centenary Issue	Rs. 50.00
2.	February, 1979	International Symposium on Tiger	Rs. 50.00
3.	September, 1984	Biomass-II	Rs. 50.00
4.	November, 1985	International Year of the Forests	Rs. 75.00
5.	December, 1985	Eucalyptus - IV	Rs. 50.00
6.	July, 1986	Brandis Memorial/Environment Conservation	Rs. 50.00
7.	October, 1988	Bamboo-II	Rs. 75.00
8.	October, 1991	Wildlife	Rs. 50.00
9.	May, 1992	Earth Summit 1992	Rs. 50.00
10.	October, 1992	Indian Forest Service 125th Anniversary	Rs. 50.00
11.	October, 1993	Wildlife	Rs. 50.00
12.	February, 1994	Vegetative Propagation	Rs. 50.00
13.	July, 1994	Joint Forest Management	Rs. 50.00
14.	September, 1994	Biodiversity - I	Rs. 50.00
15.	October, 1994	Biodiversity - II	Rs. 50.00
16.	November, 1994	Sustainable Development	Rs. 50.00

Forwarding charges will be extra. Kindly send your order to :

Business Manager,
INDIAN FORESTER
P.O. NEW FOREST
DEHRA DUN - 248 006 (U.P.)

PROVIMI

SALTLICKS

FOR CATTLE, GOATS, SHEEP, HORSES,

DEER, TIGERS, PUMAS, ZEBRAS &

Other Forest Animals.

CONTAINING:
Iodine
Iron
Copper
Cobalt
Manganese
Magnesium
Zinc
Sodium

India's Top Selling Lick !

Provimi Saltlicks are of Vital Importance for the Health of your Wildlife

Manufactured By:

Provimi Products Private Ltd.

Regd. Office: **Bangalore,**
Factory & Administration: **3-F, Mill Road, Gobichettipalayam-638476, Tamil Nadu.**
Phone: 2593, 2493, 2707 & 2059

THE
INDIAN FORESTER

VOLUME 121 JUNE 1995 NO. 6

Teak is the most important timber species of the Indian sub-continent and one of the most important in the world.

Published by Dr. N.S. Bisht, I.F.S. (Asstt. Silviculturist, Gen.) from Forest Research Institute, Dehra Dun on behalf of the Board of Management, Indian Forester, Dehra Dun. Printed by S.K. Arora at Print World, 29-Rajpur Road, Dehra Dun. Hony. Editor : Pankaj Khullar, I.F.S. (Director, Silviculture Research, Forest Research Institute, Dehra Dun).

Registered No. ***D.N. 36***